POWER

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Spending to Save

A FEW years ago the problem was to produce, let the cost be what it might. Everybody wanted everything and wanted it right then. The Government wanted munitions with which to win the war; laborers and tradesmen, exulting in exuberant wages and profits, indulged themselves in unaccustomed expenditure. The mines, the farms, the railroads and factories were run to the limit of their capacity; salesmen sat at their desks and accepted orders from favored buyers, and the problem of the management was not how cheaply but how much can we produce.

And then came a change. The war demand ceased; there was no longer a shortage of man power which enabled labor to set its price. The great middle class, which had suffered rather than profited by the war, found its income reduced by exorbitant taxes and its purchasing power impaired by the persistence of wartime prices. Nobody buys anything that he can get along without and business drags. The profit that the manufacturer made on volume of business and indifference as to price, he now has to make on economies in production. If commodities are to move in large volume and services are to be freely bought, they must be offered at prices that the purchaser is accustomed to pay, or at least at prices that he can afford to pay.

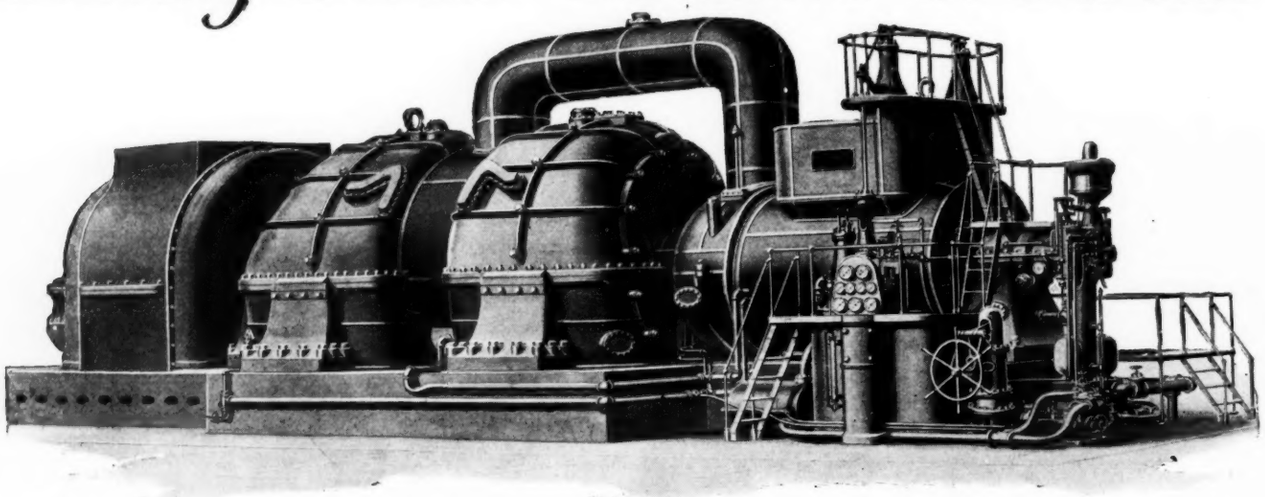
To manufacture goods at a cost that will enable them to be sold at such prices at a profit, every possible economy must be practiced.

It is time to put some of those war profits into more efficient plant.

In the power plant especially there is an opportunity for large savings. Is not this ideal time to realize them? The savings that you make will help to keep the balance on the right side, and the money that you spend for more efficient apparatus or the instruments necessary for the more intelligent conduct of your plant will help to start the tide of business into motion.

F. R. Low

Putting Steam Turbines in Service



MANUFACTURERS of large turbines have been giving considerable thought to the question of properly instructing the operating engineer on the important subject of "starting up." A chief engineer of a large station recently remarked, "Wouldn't it be wonderful if we never had to start up? I always heave a sigh of relief after these units are on the line." And rightly so. It may generally be said that the critical time in the life of a large turbine is during the process of placing it on load. Assuming that a reasonable time has been consumed in starting and the unit is safely on the line and running smoothly, what may happen afterward can hardly be laid to the process of starting.

It is not the intention in this article to deal with the operation of a turbine after it is once carrying its share of the station load, but rather to point out to the operating man the more important points in the process of attaining this objective. Any instructions of course must be incomplete; the skill and intelligence of the operator must be relied upon to take care of the minor details properly and to modify certain procedures under normal conditions of operation.

Large units may be physically divided and subdivided into three classes as follows:

A. Single-cylinder machines of the (1) single-flow, (2) double-flow and (3) semi-double-flow types.

B. Tandem-compound machines.

C. Cross-compound machines of the (1) one high-pressure and one low-pressure cylinder and (2) one high-pressure and two low-pressure cylinders.

A. The single-cylinder unit, whether it be single-flow or double-flow, is obviously the easiest one to start up, although since the expansion of steam from boiler pressure to vacuum takes place in a single shell, the extremes of temperature are more excessive from one end of the shell to the other, or from the center to the ends, than in the compound units.

AS the sizes of steam turbines increase, the problem of warming a unit up and putting it in service has become more serious. There has been much misunderstanding, and false doctrines have been preached on this very important feature of steam power-plant operation. It is therefore with considerable satisfaction that this discussion on the proper procedure to follow in starting a large turbine is presented. The starting of single-cylinder, tandem-compound and cross-compound two-and-three-cylinder machines is considered. Practices that were correct for starting large reciprocating engines, if applied to large steam turbines, are liable to lead to disaster.

Before the throttle valve is opened, the operator must make sure that certain preliminary details have had attention. Oil pressure should be established on the unit by means of the auxiliary oil pump. Start up the circulating pump and discharge full capacity through the condenser. It is also well to test all automatic valves by releasing the overspeed device and noting operation of the valves. The air pump should be running full speed, but without attempting to establish any vacuum in the condenser. It is to be assumed that all the drains on the inlet valves and steam line to turbine are open, as they should have been when the unit was shut down, to prevent an accumulation of water. Unless this is done, water will be thrown into the turbine when the throttle valve is opened. Notify the operator that everything is in readiness for the field on the generator, and when the indicator lights up the unit is ready to start.

Steam should then be admitted quickly through the throttle valve, just sufficient to start the spindle rolling slowly, and then the valve should be quickly closed again. Provided conditions are normal, the spindle will continue to roll for some time after it is given a start. During this interval the operator should listen or "sound the cylinder" for rubs or unusual noises. Assuming that he finds it "clear," he should then go back to the throttle and open it again sufficiently to keep the spindle rolling at, say, 150 r.p.m. until the turbine has become thoroughly and uniformly heated. This should be, roughly, one minute for each 1,000 kw. rating, with a minimum of ten minutes.

It is important that the spindle should revolve slowly at this stage of the

Fig. 1. Single-cylinder double-flow combination impulse and reaction type turbine. Steam from the throttle enters the casing at *A* and first passes through two rows of impulse blading at *B* and then divides. Half the steam passes through the reaction blading on the right to exhaust chamber *D*, which connects to the condenser. The other half of the steam passes up over the impulse wheels into chamber *C* and is expanded through rows of reaction blading and passes to the condenser through chamber *D'*. The rows of reaction blading are alike on both ends of the machine, and the flow of the steam is indicated by the arrows. In some type of these machines the impulse blading is omitted and the high-pressure steam enters a central chamber around the center of the casing, where it divides and flows in opposite directions through rows of reaction blading, as in the figure.

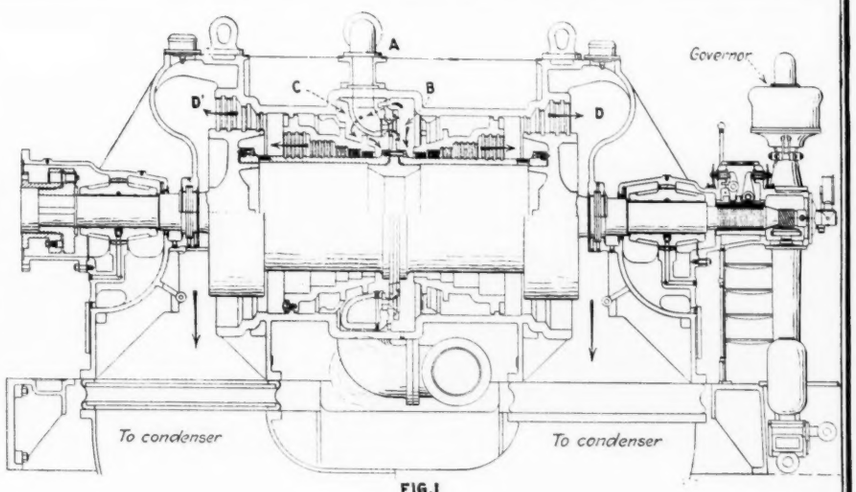


FIG. 1

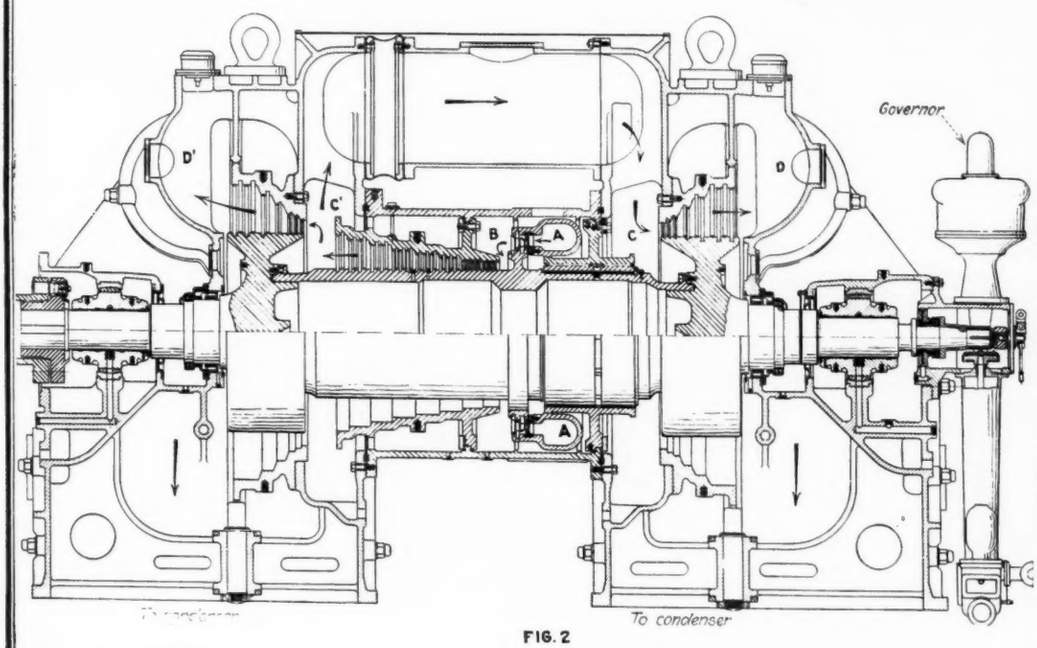


FIG. 2

Fig. 2. Single-cylinder semi-double-flow combination impulse and reaction type turbine. In this machine high-pressure steam enters chamber *A* and is expanded through two rows of impulse blading. The steam is then expanded through a number of rows of high-pressure reaction blading between chambers *B* and *C'*. At *C'* the steam divides, half of it passing to the left through rows of low-pressure reaction blading into chamber *D'* and to the condenser. The other half of the steam passes to chamber *C* on the right and through rows of low-pressure blading into chamber *D* and to the condenser as indicated by the arrows.

Fig. 3. Tandem-compound reaction-type turbine. High-pressure steam enters the turbine at *A* and is expanded through straight reaction blading; exhausting at *B* into the connection that leads to the low-pressure machine at *C*, where the steam is further expanded in a double-flow reaction-type turbine and goes to the condenser at *D* and *D'*. If the load exceeds a predetermined value, a secondary valve is opened by the governor and admits steam at *E*. Should the load exceed a second predetermined value, a tertiary valve opens and admits steam at *F* to the high-pressure element.

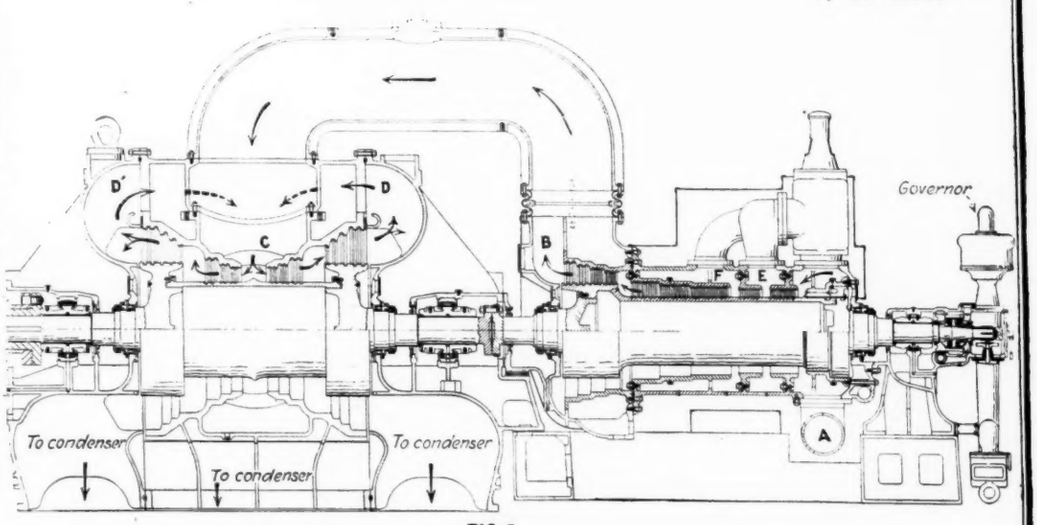


FIG. 3

operation, because if there is any tendency for the shaft to spring, due to uneven heating caused by a leaky throttle or otherwise, the speed is low enough so that the spindle has a chance to straighten out. In other words, the centrifugal force is less than the tendency to straighten. A spindle that is sprung for some reason and is allowed to accelerate to full speed without being given a chance to straighten, probably will continue to be sprung, causing vibration, blade rubs, and perhaps resulting in serious damage.

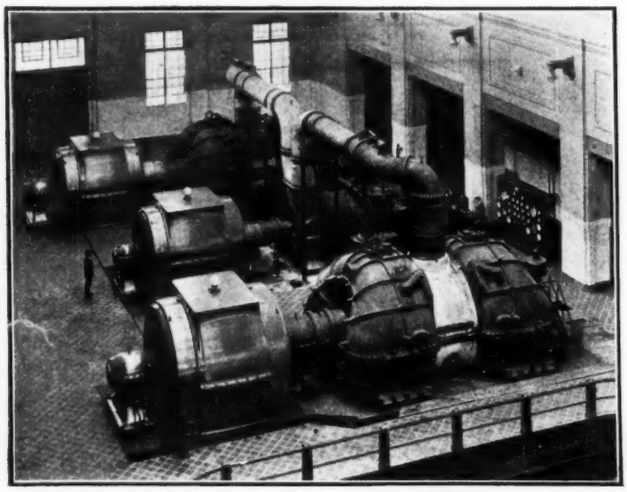


FIG. 4. CROSS-COMPOUND THREE-CYLINDER TURBINE
This machine has one low-pressure and two high-pressure cylinders. The high-pressure unit is in the center and exhausts through the overhead pipe connections into the low-pressure machines on each side of the group.

After the operator has opened the throttle to keep the spindle rolling slowly, he should close the vacuum breaker, open the valve in the air line and allow the vacuum to build up slowly to 15 in. At the same time the condensate pump should be started.

Plenty of Time Should Be Allowed for the Warm-Up Operation

Some turbines are not equipped with steam sealed glands and consequently no vacuum can be established in the condenser until after about half speed has been reached. In any event, it is important that plenty of time be allowed for the warming-up operation. Some operators complain that running the spindle slowly for a long time without being able to create any vacuum allows the low-pressure ends to get hot, whereas in normal operation these ends are cold and the change that takes place is excessive. There is some cause for complaint in this regard, but the truth, or straightness, of the spindle is of first importance and must be given careful consideration.

When the operator has assured himself that conditions are still normal, the unit should be brought up to about half-speed in a short time, consistent with safety, say three minutes. In case the unit has water seals, the glands will probably function at this speed and the steam seals can be turned off. In case of steam seals only, it is understood, of course, that they must be used at all times.

By the time the unit has reached half-speed, the operator can judge in the majority of cases, whether or not the warming operation has been done properly and the spindle is revolving true. If the machine is inclined to vibrate, the vacuum will probably be held for a time and the speed varied slightly, either up or down and the conditions observed. If satisfactory operation is obtained, the vacuum should then be allowed to come up to at least 20 in. before the turbine reaches full speed. Some operators prefer to have about 24 in. of vacuum when they are ready to synchronize and allow the load to build up slowly with the vacuum. This is good practice and is proper procedure.

Do Not Hold Turbine at Full Speed and Vacuum At No Load

All operators must guard against the practice of holding the unit at full speed with nearly full vacuum and no load. The unit should be synchronized as soon as possible after the signal is given the switchboard. Otherwise, vacuum will build up in the unit in the high-pressure section and cut down the flow of steam to a minimum, allowing practically no circulation of steam through the blading. It may be generally said that it is preferable to maintain the inlet pressure at not less than 25 lb. gage, and the operator can thus vary the vacuum to meet this pressure.

As soon as the unit has attained full speed, the drains which are open to atmosphere are closed, and when the signal is received that the unit is on the line, the throttle valve is opened wide. At the same time it should be observed that the inlet valves control the speed. Full load can then be placed on the unit gradually, occupying time equal to that used for warming up.

In the early days of the turbine the operator of reciprocating engines followed the practice with which he was familiar; that of opening the throttle valve and allowing steam to blow through, but not of sufficient amount to revolve the spindle. This was the method of warming up a unit and was followed on turbines for a number of years. As soon as large capacities began to be concentrated in single units, it was soon realized by many engineers that this practice was entirely wrong and that the warming up process must be accomplished with the spindle revolving. It must be remembered that with the Parsons type of blading the radial clearances are comparatively small, where with the Curtis type the side clearances are small. Thus a bent or warped spindle might cause mechanical contact in either case.

Practices That Distort the Turbine

If the throttle is opened only a slight amount and the steam allowed to blow through with the spindle standing idle, it is easy to visualize what is taking place inside the cylinder. The hot vapors will, of course, rise to the top of the cylinder where condensation takes place as they strike the cold walls of the cylinder. The bottom of the cylinder will then be comparatively cold. In due time the exhaust end will also be nearly as hot on top as the inlet end, while the bottom of the cylinder is much cooler. Since this is so, the upper half of the shell tends to become longer than the lower half and the spindle is also longer on top. Of course, the upper and lower halves of the casing are bolted together, with the result that both the cylinder and spindle are sprung upward. Suppose now the spindle is started revolving after warming up in this manner. When the spindle makes half a revolution, the ends of the blading in that part of the spindle which was previously on top and sprung upward, will be on the bottom, and the shaft will be sprung downward, and may strike the bottom of the

cylinder which is sprung upward. As a result a serious blade rub may develop. This may rub hard enough to bring the spindle to rest again. *Caution*: Do not try it with a large unit. On units that are known to have rubbed, it is frequently found that spindle blades have rubbed on the lower cylinder casing.

There is one large plant where it is the practice to attempt to build up a few inches of vacuum before the throttle is opened. This should not be done as either cold air or hot steam from the gland seals thrown into the turbine while not revolving is injurious. It is also just as bad practice to turn on the gland water with the spindle standing idle, as there may be sufficient volume of water to overrun the gland drain, with the result that water will find its way into the oiling system.

It is always desirable to allow the maximum time for starting. Half an hour should be the minimum on any large unit. Forty to fifty minutes is better. In the case of a compound unit more time should be allowed, as will be shown. No doubt the majority of units are started up in twenty minutes and they have been started for months and maybe years in that time satisfactorily. A well-trained crew can do so, but what *should* be done and not what *can* be done is being discussed.

The chief engineer is watching his operating cost, as he knows the stockholders are watching the coal pile. This no doubt prompted one chief engineer, when advised to allow more time for starting, to remark: "That is all very nice, but there is no coal mine at my back door!" And the turbine manufacturer could have retorted, "Our shop is not there, either."

Warming-Up Tandem Compound Machines

B. The tandem-compound unit consists of a high-pressure cylinder and a low-pressure cylinder, their spindles being coupled together and connected to a single generator (see headpiece and Fig. 3). The method of procedure in starting is the same in this case as in the first, except in some minor details of operation. Of course, if the structure is larger, owing to larger capacity or lower rotative speed, somewhat longer time must be allowed in warming up the machine.

Units of tandem-compound construction usually have the glands on the two elements both steam- and water-sealed, and it is desirable in coming up to speed to hold a higher vacuum on the low-pressure element—in other words, maintain the low-pressure element at nearly operating temperature, since the movement due to expansion on the throttle end of the high-pressure cylinder takes place from a point near the coupling between the turbine spindles and generator rotor. This expansion in some cases may be as great as $\frac{3}{8}$ in. Approximately one hour should be allowed on a 35,000-kw. unit of this construction, from cold condition to synchronizing.

C. The cross-compound unit differs from the preceding case in that each element has its own generator. Consider the three-cylinder unit, Fig. 4, with high-pressure and two low-pressure cylinders. It is customary in starting to tie the elements together electrically so that, as steam is admitted through the throttle on the high-pressure element, all three elements begin revolving together. Since there are four condensers, each one must be passing the full amount of circulating water. In testing the overspeed device there are more automatic valves to operate than with the other types. With the exception of these details the same procedure should be followed as in the case of the tandem unit.

It is quite natural for the operator to ask what should be done when conditions are abnormal. Let it be assumed that there is a suspicion of a blade rub immediately after the spindle is first started. No doubt the operator has familiarized himself with the fact that a certain inlet pressure is required for starting and this has not been exceeded. If there is still a suspicion and the apparent rub does not clear itself, the unit should be allowed to come to rest, or at least to lower in speed until the sound ceases. Another attempt can be made to start when the operator is satisfied that the rub has cleared and if found clear can then be started in the usual manner. Suppose it is definitely determined that a distinct rub can be heard; it then must be determined whether it is serious enough to demand making an internal examination.

There is normally no excuse for a blade rub in starting. The common cause is a leaky throttle valve. This should be remedied at once. Another common cause is to open the throttle *slowly* and not quickly. It is surprising how quickly a long spindle will distort if this program is followed. The operator should be careful not to allow blade rubs in starting as the manufacturer has carefully calculated the minimum blade clearance. Continued blade rubs will increase this clearance and the efficiency of the unit will be decreased.

Calculating Size of Wire for Armature Coils

Where an electrical machine is to operate on one-half the voltage that it was originally designed for, the number of turns in the winding connected in series must be reduced by one-half. Since the number of turns is reduced by one-half, the cross-section of the conductors in each coil can be increased by two. On the other hand, if the voltage is reduced by 4 the number of turns in series must be reduced by 4 and the size of the copper can be increased by 4. Conversely, if the voltage is increased by 2 the number of turns must be increased by 2 and the size of the copper reduced to one-half. This is easily figured out by mental arithmetic. However, if the voltage is increased or decreased by, say, 25 per cent, the size of copper may not be so easily determined by those who do not have their arithmetic on their finger tips.

For example, take the case where the coils of a 120-volt armature are wound with 8 turns of No. 12 copper and it is desired to rewind the machine for 90 volts. The number of turns per coil will vary directly as the volts, and is equal to, $\frac{New\ volts \times Original\ turns}{Original\ volts} = \frac{90 \times 12}{120} = 9\ turns$. No. 12 copper has a cross-sectional area of 6,530 circ.mils, and since there are 12 turns in the original coil, there is $6{,}530 \times 12 = 78{,}360$ circ.mils cross-section in the coil conductors. Now the new coil should have approximately the same cross-section of copper. Therefore if the original cross-sectional area of the coil in circular mils is divided by the new number of turns, the new size of wire will be obtained. In this problem $78{,}360 \div 9 = 8{,}703$ circ.mils. The nearest standard size of wire to this is a No. 11, which has 8,234 circ.mils cross-sectional area. From the foregoing it is seen that the one thing to remember is that the new turns in the coil must have approximately the same total cross-sectional area as the original turns.

Maintaining Heat Balance at Hell Gate

With the exception of a few stand-by units, all of the auxiliaries in the Hell Gate Station are electrically driven by 60-cycle alternating-current motors. Most of the auxiliaries may take their power either from the main bus through a transformer bank or from the 2,300-volt house-turbine bus. These buses are not connected in any way. Before being heated by the house-turbine exhaust, the feed water passes through closed heaters supplied with steam bled from the main turbines. The control of the heat-balance and of house turbines is centered in a gallery above the operating floor.

IN THE general article on the new Hell Gate Station of the United Electric Light and Power Co. in the May 2 issue of *Power*, and also in the article (describing the boilers and their auxiliaries) in the May 9 issue, mention was made of the system of heat balance employed at this station. Before proceeding to describe the Hell-Gate system, a few general remarks on the subject of heat balance may not be out of place.

The term "heat balance" may be used to refer to a thermal balance of the heat entering and leaving each part of a system, or it may be understood to refer to the arrangement and control of apparatus in the heat cycle to secure operation with the least possible waste of heat.

It is only during the last few years that engineers in general have come to realize that the question of heating feed water economically is not simply a matter of supplying enough exhaust steam. From the point of view of station economy there are two main considerations. The first is to heat the feed water with steam from which every possible foot-pound of useful energy has been abstracted. The second is to drive the auxiliaries with the minimum amount of power, consistent with the proper performance of their work.

The extent to which these conditions may also be profitably realized is not simply a matter of balancing capital charges and operating costs against the thermal saving. Continuity of service also must be considered. Nothing must be done in the search for economy that might increase the possibility of a shutdown or make it more serious.

With these considerations in mind several different systems of maintaining an economical heat balance have been installed in large central stations recently erected. In practically every instance the system is closely connected with the driving of the station auxiliaries; yet such drives are not necessarily related to the heat-balance system. For example, good over-all economy can be secured by driving all the station auxiliaries electrically, and heating the feed water by passing it through a series of heater condensers supplied with steam bled from the main turbine at several points. With this arrangement feed-water heating is entirely independent of the operation of the auxiliaries. The objection to this system is that it exposes the auxiliaries to possible disturbances on the main bus. This danger may be reduced by providing some of the more essential units (such as the feed pumps, for example)

FIG. 1. VIEW IN CONTROL GALLERY OVERLOOKING OPERATING FLOOR

The board on the left is for control of the house turbines while that on the right carries the instruments for heat-balance control.

with turbine or duplex (motor and turbine) drive or by installing stand-by units with turbine drive. Where a large proportion of the auxiliaries are electrically driven, it is customary to install one or more "house turbines" to carry part or all of this load. In this case turbine or duplex drives may still be provided for certain auxiliaries as an additional precaution. Likewise one or more bleeder connections to the main turbines may be retained.

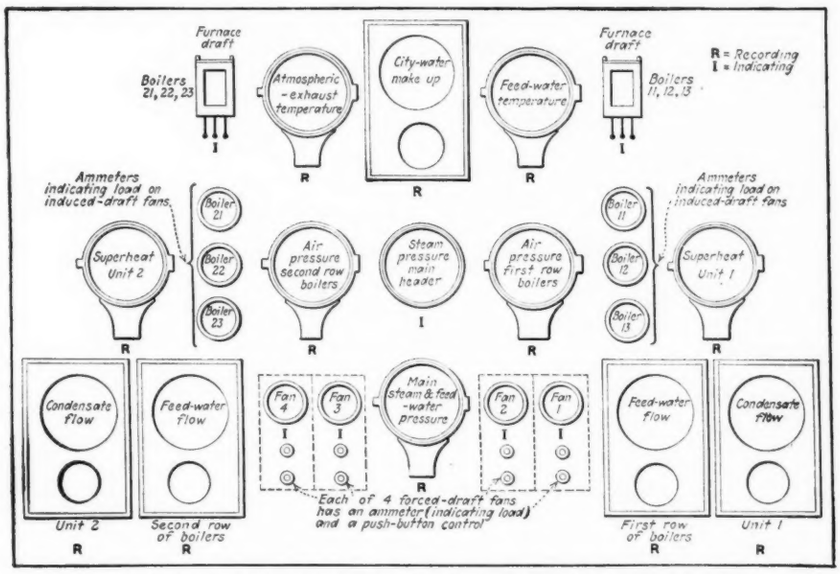


FIG. 2. HEAT-BALANCE CONTROL BOARD SHOWING INSTRUMENTS AND PUSH BUTTONS FOR ONE GROUP

The auxiliary load does not vary in direct proportion to the station load. Therefore the feed-water temperature could not be held constant (except by the use of bleeder steam) if the house turbine operated with a fixed back pressure and carried a constant percentage of the auxiliary load. For this reason it is generally made possible to vary one or both of these elements. Ordinarily, the auxiliary load is divided between the main bus and the house-turbine bus, with provision for varying the percentage carried by each as the station load changes. The buses may be tied together through transformers, or by a motor-generator set. The latter, if properly installed, serves to protect the auxiliary bus from main-bus disturbances. A simpler method is to keep the two buses entirely independent with provision for switching any of the auxiliaries from one bus to the other. This is the plan adopted at Hell Gate.

The salient features of the Hell Gate heat-balance system are as follows:

1. All station auxiliaries, except certain stand-by units, driven by 60-cycle alternating-current motors.

2. Division of the station into four independent groups (two now installed), each having its own auxiliaries and heat-balance system, including one 2,000-kw. 2,300-volt house turbine exhausting at 1 lb. gage, and two bleeder connections from each main unit.

3. Centralized control of the group heat balances from a gallery above the operating floor.

Fig. 4 is a diagram of the heat balance system for one group. As the station has been in operation only a short time, no data are yet available for determining the amounts of heat flowing through the various parts of the system. However, approximate temperatures have been indicated at certain points.

While the piping (as well as the apparatus) has been idealized and simplified, the connections shown are equivalent in practically every case to those in the actual plant. The chief exceptions are indicated by notes on the diagram.

The diagram was prepared on the basis of an average load of 26,200 kw. on each of the main units. This is the point of best economy.

The indicated equipment involved in the heat balance of one group may be briefly summarized as follows:[1]

Boilers — Six 18,900-sq.ft. water-tube boilers, double-fired with underfeed stokers and producing steam at 250 lb. gage and 200 deg. superheat.

Sixty-Cycle Main Generating Unit and Auxiliaries — One 40,000-kw. three-phase 13,200-volt tandem-compound turbo-generator exhausting to a 50,000-sq.ft. surface condenser; oil cooler with storage tank and booster pump for cooling water.

Twenty-five-Cycle Main Unit and Auxiliaries — One 35,000-kw. three-phase 11,400-volt single-cylinder impulse turbo-generator exhausting to a 50,000-sq.ft. surface condenser; oil cooler using same storage tank and booster pump as 60-cycle unit (these are shown in duplicate on diagram for simplicity); eductor condenser for the gland-packing leak-off steam of turbine, air-ejector condenser on unit condenser.

House Turbine—One 2,000-kw. (2,500-kva.) three-phase 60-cycle 2,300-volt unit exhausting at 1 lb. gage.

Closed Heaters—Two of 350,000-lb. per hour capacity.

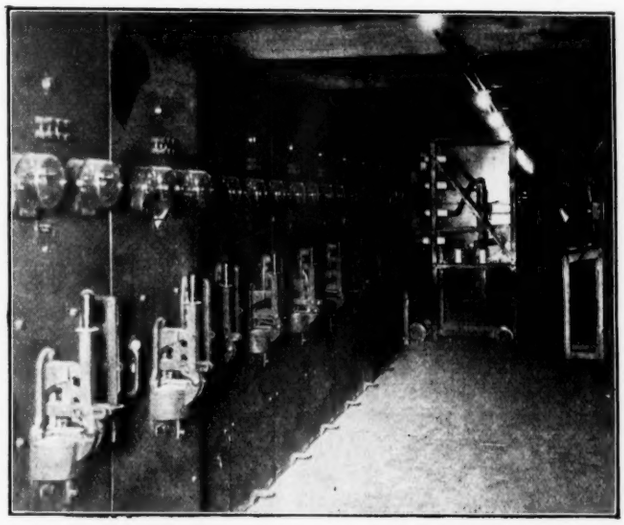


FIG. 3. TRUCK-SWITCH ROOM IN BOILER-ROOM BASEMENT

The truck switches shown are for connecting the various auxiliaries to one of the buses. A similar row for the other bus is placed back to back with this.

Open Heater—One of 1,000,000-lb. per hour capacity.

Feed pumps—Three 1,000-gal. per min. centrifugal pumps (two normally on line).

Surge Tank—One, in boiler room about twenty feet

[1]For more complete description of the apparatus see the May 2 and May 9 issues of *Power*.

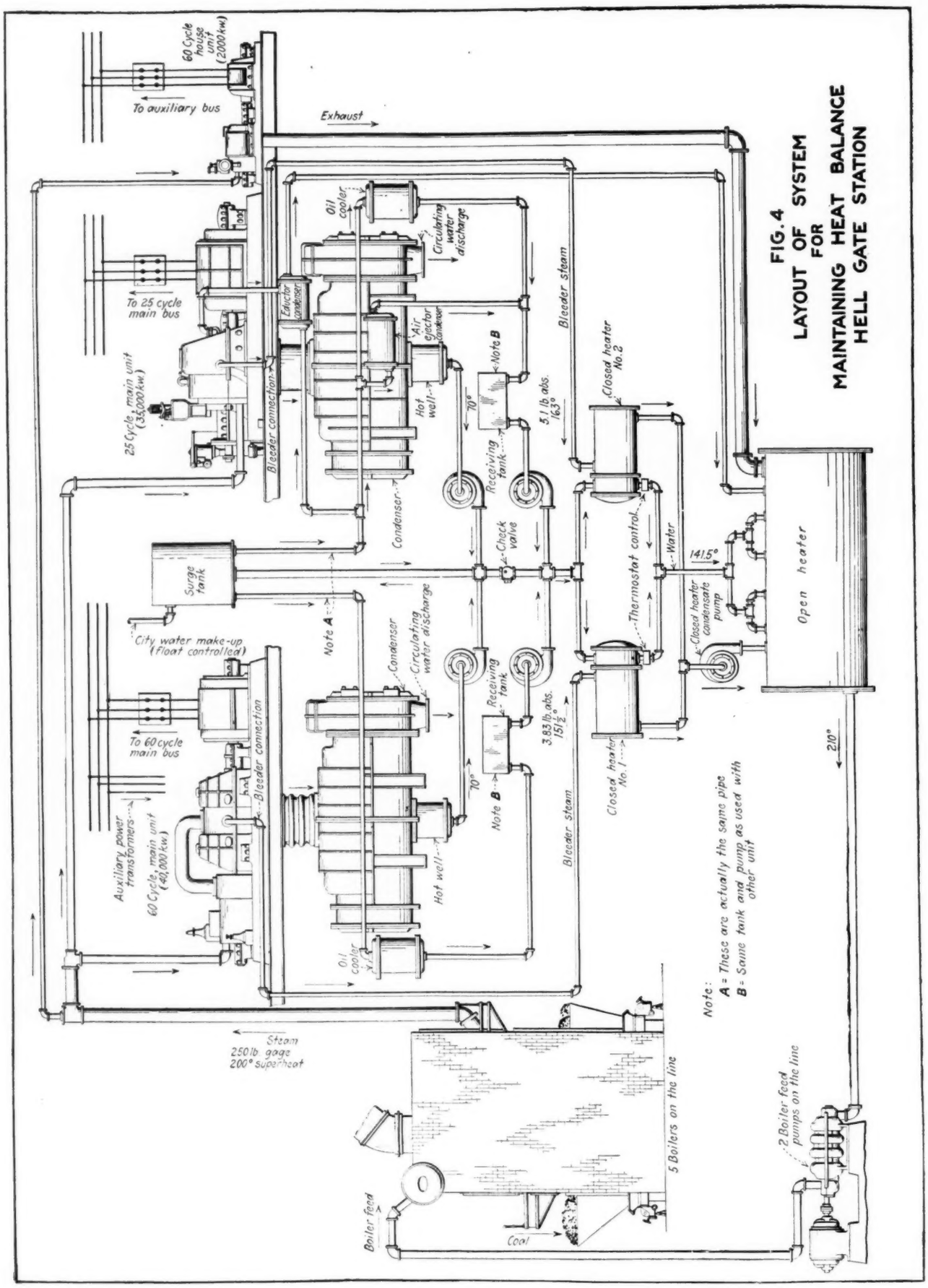


FIG. 4
LAYOUT OF SYSTEM
FOR
MAINTAINING HEAT BALANCE
HELL GATE STATION

above operating-room floor and supplied with city-water makeup through float-controlled valves.

City water makeup, entering the surge tank through the float-controlled valves, passes through the closed heaters to the open heater and then through the closed pumps to the boilers. As steam it leaves the boilers and is carried to the main turbines and the house turbine. The steam leaving the main turbines is condensed and delivered by the condensate-pump discharge lines to the line running from the surge tank to the closed heaters. From this point the condensate normally passes down to the closed heaters, although it may flow up into the surge tank if there is a temporary over-supply of feed water.

A second pipe leading from the bottom of the surge tank has two branches (shown on the diagram as two independent lines from the surge tank), one of which goes to the oil cooler on the 40,000-kw. unit, while the other supplies the oil cooler, air-ejector condenser, and packing-steam-eductor condenser of the 35,000-kw. unit.

The discharge from the packing-steam-eductor condenser is carried directly to the open heater. That from the other apparatus just mentioned is carried to a receiving tank. From this it is delivered by a booster pump to the line connecting the surge tank and the closed heaters at a point below the delivery point of the hotwell pumps. To avoid confusion due to the crossing of pipes, the diagram shows two receiving tanks although there is actually but one. There are two booster pumps, one of which is held in reserve.

The check valve shown in the line from the surge tank to the closed heaters, between the points where the condensate and the hot water from the receiving tank come in, prevents the latter from rising and mixing with the cooler condensate.

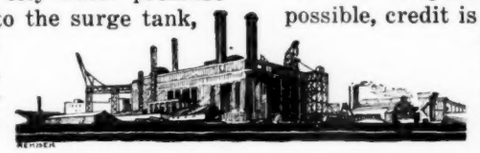
Thermostat Control on Closed Heaters

By means of thermostat-controlled valves on the outlet side of the closed heaters, the total flow through them is proportioned so that the water leaves both at the same temperature. These valves do not restrict the total flow, but merely divide the water in proportion to the heat supplied to the heaters by the steam bled from the main turbines at a pressure ranging from 7 lb. absolute to 4 lb. absolute according to the load. This steam heats the feed water to about 150 deg. F.

From the closed heaters the water goes to the open heater, the total flow being regulated by a float-controlled valve on the latter. The condensed bleeder steam is also delivered to the open heater by a condensate pump. Most of the remaining heat needed to raise the temperature of the water to 210 deg. in the open heater is furnished by the house-turbine exhaust. From the open heater the water flows to the boiler-feed pumps.

If the water from the hotwells, oil coolers, etc., is greater than the demand of the open heaters, the excess flows to the surge tank which has an overflow.

In the event of any of the closed or open heaters being out of service, water can be bypassed around the particular unit that is down or, if necessary, can be run through the open heater of the next group or direct to the boiler-feed pumps. If the city-water pressure falls too low to put the makeup into the surge tank, an emergency connection may be made direct to the feed pumps. If for any reason the house turbine does not furnish enough exhaust steam to maintain the water in the open heater at 210 deg. a pressure-controlled valve opens when the heater pressure drops below 1 lb. gage, and bleeds steam from one of the main turbines. In case this is not enough, the same control opens a similar valve on the other main turbine. These emergency bleeder connections are not shown on the diagram. Pressure-reducing valves in the bleeder lines protect the open-heater from excessive pressure.



Mention has already been made of the fact that the heat balance is controlled from a gallery above the operating-room floor. The general appearance of this gallery is shown in Fig. 1 while Fig. 2 shows the layout of heat-balance control instruments for one group of boilers. Practically the only manual regulation required for securing the proper heat balance is the control of the forced-draft fans, which are operated by the push-button switches shown on the control board. This is made possible by the fact that variations in load, and hence in heat requirements, are small in the normal operation of this plant. By arranging to have the normal exhaust of the house turbine less than the open heater requirements, ordinary fluctuations are cared for by the automatic bleeder valves.

The truck-switch room shown in Fig. 3 is used only when it is necessary to shift any auxiliary from the main bus to the house-turbine bus or the reverse. There are two rows of switches like that shown, one row for each bus, with individual truck-switch sections for the various auxiliaries.

Auxiliary Drive

Returning to the question of auxiliary drive, the only steam-driven auxiliaries in the plant are one fire pump, one feed pump in each group of three and one of the two exciters for each house alternater. All of these are stand-by units so that no steam-driven auxiliaries are running during the normal operation of the plant.

The power for the auxiliaries from the main station bus is transformed from 13,200 volts to 2,300 volts by means of two 7,500-kw. power banks in the boiler-room basement. All motors over 25 hp. are operated at 2,300 volts except that 220-volt motors are used in the skip hoist and 440-volt in cranes and coal towers. Motors of 25 hp. and less are wound for 220 volts.

The types of motors used for the various auxiliaries are as follows:

Induced- and Forced-Draft Fans — Brush-shifting variable speed.

Boiler-Feed Pumps—Variable-speed wound-rotor induction.

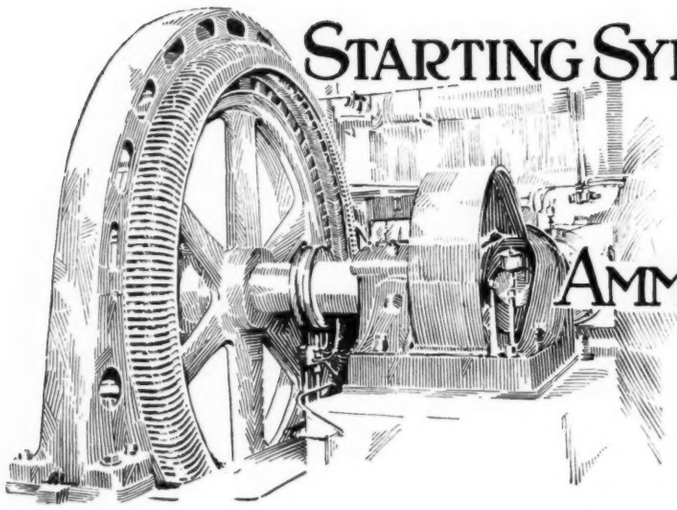
Stokers—Constant-speed squirrel-cage with variable-speed transmission.

Clinker Grinders—Two-speed squirrel-cage.

Other Auxiliaries—Constant-speed squirrel-cage.

The alternating-current system of auxiliary drive used in this plant was not adopted until a careful study had been made of the following systems: (a) All steam, (b) steam and direct current, (c) steam and alternating current, (d) direct current, (e) alternating current.

For the co-operation which has made this article possible, credit is due to Frank W. Smith, vice president and general manager of the United Electric Light & Power Co., and to Thomas E. Murray, Inc., designing and constructing engineers.



STARTING SYNCHRONOUS MOTORS *Driving* AMMONIA COMPRESSORS

By

*A. R. Stevenson, Jr.**

OWING to the fluctuations in general business conditions during the last few years the progress in a particular industry can be measured only by comparing it with some other older and well-established industry. In 1919 and 1920 one large electrical manufacturing company sold one-half as many synchronous motors to drive ammonia compressors as it sold for air compressors. But in 1921 this same company sold more synchronous motors to drive ice machines than to drive air compressors, and in the first month and a half in 1922 the number of synchronous motors sold for refrigerating plants was almost three times the number sold for connection to air compressors. This shows that the number of synchronous motors driving ammonia compressors has increased amazingly.

Application of Synchronous Motors to Ammonia Compressors

In the ordinary application of synchronous motors to air compressors and pumps, when starting unloaded, starting the motor is generally a simple operation. It usually consists of connecting the stator windings to the low-voltage taps on the starting transformers; when the motor comes up to near synchronous speed, the field switch is closed to the source of excitation and the motor pulls into step. The motor is then connected to full voltage and the machine is ready to carry its load. Under severe conditions it is often necessary to connect the stator winding to full voltage before closing the field switch, so as to get the motor near enough to synchronous speed so that it will pull in after excitation is applied. The problem of the application of synchronous motors to ammonia compressors is, in general, more difficult than with air compressors for several reasons:

1. Many ammonia compressors run at slower speed and therefore require larger flywheels.

2. The larger the flywheel the greater will be the starting torque required to accelerate the compressor, and the large flywheel also makes it more difficult to obtain the necessary pull-in torque.

3. Ammonia compressors cannot be unloaded to the atmosphere, therefore a bypass is necessary. If this is not large enough, the power required to force the gas through the pipes while bringing the compressor up to speed may be excessive.

4. It is more difficult to build slower-speed synchronous motors for high starting and pull-in torque than to build high-speed machines.

THE applications of synchronous motors are increasing rapidly, and each new application brings up new problems. In this article the author, who for a number of years has made an exhaustive study of the subject, discusses the different methods of starting synchronous motors when applied to ammonia compressors, especially slow-speed machines. In these applications the size of the bypass has a marked influence. Where bypasses have been too small, a special scheme of starting was developed, which pumps out the cylinders through the discharge valves, after which the motors come up to speed easily.

Motors Require Higher Starting Torque

All these reasons make it necessary for a synchronous motor applied to an ammonia compressor to have not only a higher starting torque, but also a higher pull-in torque than for air-compressor work. This may lead to complications in starting not ordinarily experienced with other applications. The characteristics of the motor are such that it is difficult to incorporate in the same motor high starting and high pull-in torque. A high-resistance starting winding gives a good starting torque, but decreases the pull-in torque. The slip of the rotor for a given load increases with the resistance of the starting winding, therefore the higher the rotor resistance the greater the difference between the speed at which the motor will run when operating as an induction motor before closing the field switch, and synchronous speed. Increasing the slip of the rotor makes it more difficult for the motor to pull into step. On the other hand, with a low-resistance starting winding and the motor loaded within its limit, the slip will be reduced and the motor will pull into step more easily than with a high-resistance starting winding, but the starting torque will be reduced.

Since the ammonia compressor cannot be unloaded to the atmosphere like an air compressor, the gases must be bypassed

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from one end of the cylinder to the other during starting and this increases the load on the motor, especially during the pull-in period. The importance of a large-sized bypass cannot be over-emphasized, since the pressure drop in a bypass carrying ammonia vapor varies as the square of the velocity and as the density. From this it is evident that if the bypass on the compressor is small, the load on the motor will build up very quickly as the machine comes up to speed, owing to the pressure drop through the connections between the two ends of the compressor cylinder. Such a condition may make it impossible for the motor, when started in the usual manner, to get the compressor up to a speed where it can pull into step. However, means have been developed whereby such conditions can be overcome. In one of these installations where the bypass was too small, it was closed quickly after the motor had reached about 50 per cent synchronous speed, and the motor slowed down enough to allow the stored energy in the flywheel to assist in opening the discharge valve and emptying the cylinders, after which the motor came up to speed easily.[1]

Tests Made on Synchronous Motor Directly Connected to Ammonia Compressor

The author has made some tests on a 600-hp. 80-r.p.m. 440-volt synchronous motor direct-connected to an ammonia compressor. The compressor is of the compound double-acting type and has two cylinders, one 16½ in. and the other 42 in. in diameter, and a 42-in. stroke, with the cranks at right angles. A large flywheel was necessary since one cylinder of the compressor is larger than the other and the machine runs with only one cylinder connected during the winter months. This

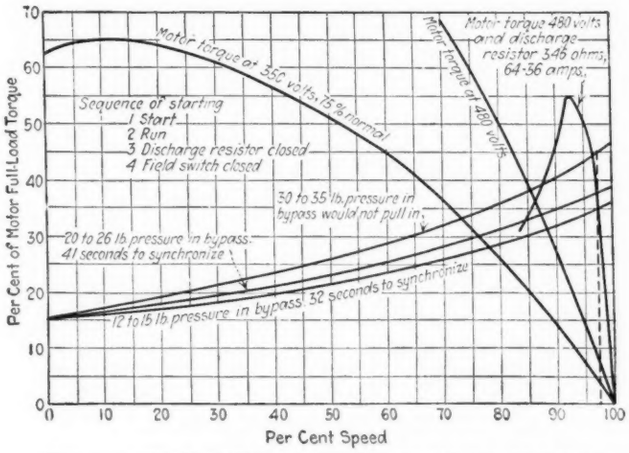

Per Cent of Motor Full-Load Torque
Per Cent Speed
Motor torque at 350 volts, 75% normal
Motor torque 480 volts and discharge resistor 3.46 ohms, 64-56 amps.
Motor torque at 480 volts
Sequence of starting
1 Start
2 Run
3 Discharge resistor closed
4 Field switch closed
30 to 35 lb. pressure in bypass would not pull in
20 to 26 lb. pressure in bypass. 41 seconds to synchronize
12 to 15 lb. pressure in bypass. 32 seconds to synchronize

FIG. 1. SPEED-TORQUE CURVES OF 600-HP. 80-R.P.M. SYNCHRONOUS MOTOR

flywheel has 1,255,000 WR^2 and weighs 42,506 pounds, or approximately 21 tons.

The bearings of this compressor are exceptionally good, and in spite of this 21-ton weight on the shaft the static friction was only 15 per cent of the full-load torque when measured after the installation had been shut down for eights hours.

Fig. 1 shows the speed-torque curves of this synchronous motor with 75 per cent voltage impressed and the fields open-circuited and with full voltage impressed and the fields short-circuited through a discharge resistor of 3.46 ohms.

[1]This scheme was first suggested to the author by C. R. Neeson.

In order to check these speed-torque curves and especially to determine the torque required by the compressor while coming up to speed, the following experiment was performed:

A. The kilowatt input, the current and the speed of the motor were read every five seconds while bringing the compressor up to speed.

B. The resistance of the motor being known, the

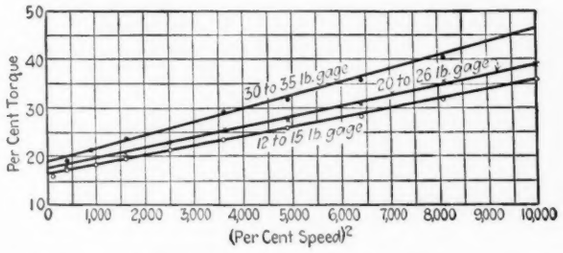


FIG. 2. CURVES OBTAINED BY PLOTTING TORQUE AGAINST SPEED SQUARED

These curves show that the power loss in the bypass varies as the square of the gas velocity in the bypass.

I^2R loss in the stator was calculated for each of the readings given.

C. This I^2R loss was subtracted from each of the kilowatt readings. The remainder was the synchronous torque in kilowatts. This was divided by the rating of the motor in order to obtain the per cent torque values shown in the figures.

D. Speed-time curves were plotted from the readings of speed and time. The slope of the tangent to the speed-time curve at any point represents the acceleration at that point.

E. The WR^2 of the motor and the flywheel being known, the torque necessary to produce this acceleration could be calculated.

F. Subtracting the torque necessary for acceleration from the torque of the motor left the torque required by the compressor.

G. The torque required by the compressor, obtained in the manner stated, is shown for three conditions—with 30 to 35 lb. pressure in the bypass, with 20 to 26 lb. pressure in the bypass and with 12 to 15 lb. pressure in the bypass.

Large Flywheel Made It Difficult for Motor to Pull Into Step

Owing to the large flywheel it was found necessary, in this case, to bring the motor to 97½ per cent speed in order that it could pull into step when the field poles were excited.

Fig. 1 shows that the pull-in torque required by the compressor at 97½ per cent speed varied from 30 per cent with 12 to 15 lb. pressure in the bypass to 45 per cent with 30 to 35 lb. pressure in the bypass. From a study of these curves it is seen that with 75 per cent normal volts applied to the stator winding and the field circuit open, the motor is capable of accelerating the load only to about 73.5 per cent synchronous speed with 30 to 35 lb. in the bypass, and to about 77.5 per cent speed with 12 to 15 lb. gage pressure in the bypass. On throwing the stator winding to full voltage, which in this case was about 10 per cent above normal, the motor attained 85.5 per cent speed with 35 lb. in the bypass and 88.5 per cent speed with 12 to 15 lb. in the bypass. Even with the lower pressure the motor was not capable of bringing the compressor to a speed

where it could pull into step when the field switch was closed.

To get the motor up to speed where it could synchronize when the field coils were excited, it was necessary to close the field circuit to the discharge resistance of 3.46 ohms resistance. It is interesting to note that the motor, when connected in this manner, developed 55 per cent full-load torque at 92.5 per cent synchronous

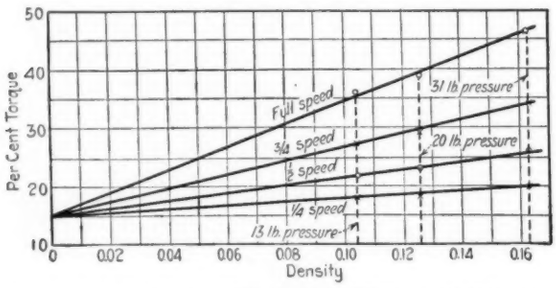


FIG. 3. CURVES OBTAINED BY PLOTTING AMMONIA GAS DENSITY AGAINST TORQUE

speed. However, as already pointed out, on account of the heavy flywheel on this compressor it was necessary to get it up to 97.5 per cent synchronous speed before the motor could pull into step. The curves show that the motor could only get the compressor up to this speed, with 20 to 26 lb. or less in the bypass. With 20 to 26 lb. in the bypass the motor could accelerate the compressor and pull it into step in 41 seconds, and with 12 to 15 lb. in the bypass it could pull into step in 32 seconds. With 30 to 35 lb. pressure in the bypass the motor could not pull the compressor into step.

The sequence of starting was first to connect the motor to 75 per cent line volts; after it had accelerated to about 70 per cent normal speed, full line voltage was applied, after which the field circuit was closed to the discharge resistance; then, when the machine had reached about 97.5 per cent full speed, the field switch was closed to the source of excitation.

Pressure Drop in Bypass Varies as the Square of Gas Velocity and As the Density

Previous experience with the flow of steam through pipes suggested that the head lost in the bypass would vary as the square of the velocity of the gas through the bypass. In order to check this suggestion, curves of torque required by the compressor were replotted against the square of the speed, as shown in Fig. 2. It will be seen that the torque required by this compressor plotted against the square of the speed is a straight line in each case. This shows that the power lost in the bypass varies as the square of the velocity of gas through the bypass.

An examination of steam formulas for the loss of head in steam pipes would show that this loss would be proportional to the density of the steam. The torque required by the compressor at full speed, ¾ speed, ½ speed, and ¼ speed, was plotted against the density as shown in Fig. 3. It can be noted that the lines representing the torque required by the compressor plotted against the density are approximately straight.

The experimental evidence just quoted shows that the pressure drop in a bypass carrying ammonia vapor varies as the square of the velocity and as the density. It was, therefore, assumed that the formula for pressure drop in pipes carrying ammonia vapor is the same as the formula for pressure drop in steam pipes.

$$P_1 - P_2 = \frac{V^2 L \left(1 + \frac{3.6}{d}\right) D}{144 \times 454 \times d}$$

where

V = Velocity in feet per second;
L = Length of pipe in feet;
d = Diameter of pipe in inches;
D = Density of ammonia in pounds per cubic foot;
$P_1 - P_2$ = Pressure drop in pounds per square inch in ammonia pipe line for various sizes of pipe and various velocities of gas in the pipe.

This formula was given by Prof. H. J. Macintire in the Nov. 2, 1920, issue of *Power*, page 703.

A bypass is not usually very long, but each 90-deg. ell offers a resistance approximately equivalent to a length of pipe 100 times its inside diameter and each globe valve offers a resistance equivalent to a length of pipe 200 times its inside diameter. For accurate values of lengths of pipe equivalent to angles and valves see "Loss Through Pipe Line Fittings," by Dean E. Foster, A. S. M. E., December, 1920.

The bypass of this compressor was so small that the resulting gas speed was 455 ft. per sec., or 27,300 ft. per min. If the reader is familiar with the calculation of pressure drop in steam pipes, it will be realized at once that large pressure drops can be expected with this high velocity. The experiment cited shows that at full speed it took 46½ per cent torque to run the compressor with 35 lb. gage pressure in the bypass. This percentage is based on 600 hp. Only 15 per cent could be accounted for by friction, which left 190 hp. which was consumed in pushing the gas through the bypass. By applying the foregoing formula, it can be shown

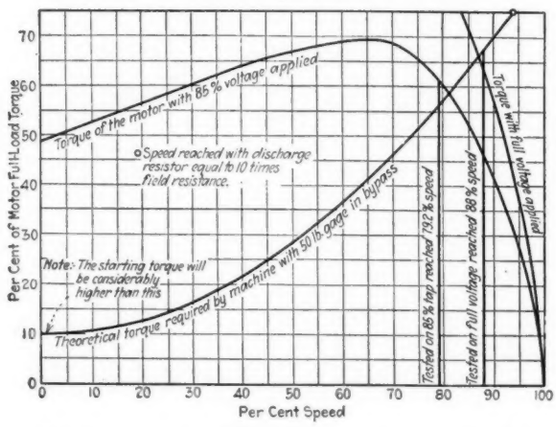

Per Cent of Motor Full-Load Torque
Per Cent Speed
Torque of the motor with 85% voltage applied
Speed reached with discharge resistor equal to 10 times field resistance.
Note: The starting torque will be considerably higher than this
Theoretical torque required by machine with 50 lb. gage in bypass
Tested on 85% tap reached 79.2% speed
Tested on full voltage reached 88% speed
Torque with full voltage applied

FIG. 4. SPEED-TORQUE CURVES OF A 300-HP. 100-R.P.M. SYNCHRONOUS MOTOR

that this loss could easily be expected in a bypass with this high gas velocity having four angles and a globe valve.

Fig. 4 shows a similar set of tests on a two-cylinder, double-acting compressor driven by a 300-hp. 100-r.p.m. motor that had too small a bypass. The cylinders were 12 in. diameter with a 36-in. stroke. These tests were much simpler than those previously outlined. The speed-torque curves of the motor were known from tests at the factory before the motor was shipped. It

was found that with 50-lb. pressure in the bypass the motor with 85 per cent voltage would bring the compressor to only 79.2 per cent speed, and on full voltage with the field open-circuited it would bring the compressor to only about 88 per cent speed. The circle on the upper end of the curve showing the theoretical torque required by the machine with 50-lb. gage in the bypass, indicates that 75 per cent full-load torque is required to bring the motor up to about 94 per cent synchronous speed. This speed was reached with the field coils connected to a resistance equal to ten times the resistance of the field circuit.

Extending the theoretical torque curve, Fig. 4, shows that the motor would have to develop about 80 per cent torque at 98 per cent speed in order to pull the load into step with 50 lb. gage pressure in the bypass. This is a very difficult requirement for a slow-speed synchronous motor. Furthermore, the actual torque required to start the compressor will be higher than that indicated by the theoretical torque curve. The fact that the motor could develop 75 per cent full-load torque at 94 per cent synchronous speed is a good indication of the excellence of the modern synchronous motor.

It is very seldom necessary to start with more than 20 or 30 lb. pressure in the bypass, but at this particular plant it was desired to be able to start with 65 lb. pressure in the bypass. In order to get successful operation under this extreme condition, the method of unloading the compressor was changed.

This special method of unloading is illustrated by Fig. 5. The compressor was started with the bypass open and a gage pressure of 95 lb. in it. As soon as the motor had turned over two or three times, the bypasses were closed as quickly as possible. The torque went up above that developed by the motor and the machine began to slow down, but the flywheel carried it over several revolutions until all the gas in the com-

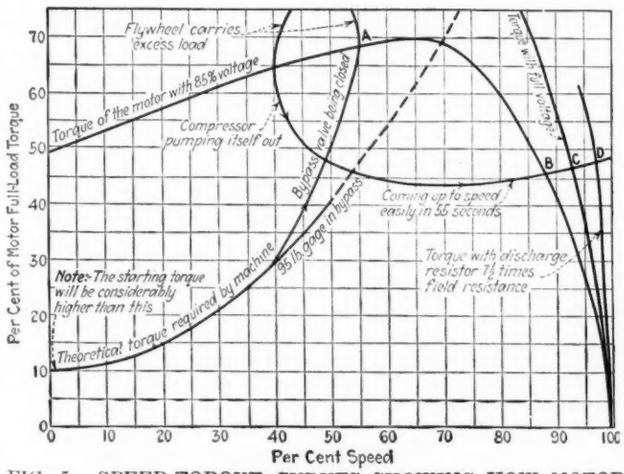

Flywheel carries excess load
A
Torque of the motor with 85% voltage
Compressor pumping itself out
Bypass valve being closed
Coming up to speed easily in 55 seconds
B
C
D
Torque with discharge resistor 7½ times Field resistance
95 lb. gage in bypass
Note-The starting torque will be considerably higher than this
Theoretical torque required by machine
Per Cent of Motor Full-Load Torque
Per Cent Speed

FIG. 5. SPEED-TORQUE CURVES SHOWING HOW MOTOR OPERATED TO OPEN DISCHARGE VALVES ON COMPRESSOR AND BRING IT UP TO SPEED

pressor had been pumped into the discharge. Then there remained a partial vacuum in both ends of the cylinders. The force necessary to push the pistons back and forth was reduced, and the compressor came up to speed easily in 55 seconds, as shown by the curves.

In Fig. 5 it will be seen that after the theoretical torque curve crosses the motor torque curve with 85 per cent voltage, at *A*, the former begins to loop backward. Beyond *A* the load of the compressor exceeds the torque of the motor and the machine begins to slow down. This allows the flywheel to give up some of its stored energy and this, combined with the motor torque, is sufficient to open the discharge valves and pump the cylinders out. This curve goes to a maximum at the top of the loop where the discharge valve opens and then, as the cylinders are pumped out, the curve

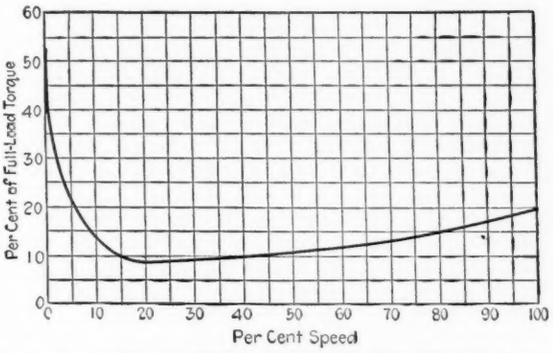


FIG. 6. STARTING SPEED-TORQUE CURVE OF AN AMMONIA COMPRESSOR WITH LARGE BYPASS

loops down as the load on the motor is reduced and it speeds up. With 85 per cent voltage applied, the motor can accelerate the compressor to about 88 per cent speed. When full voltage was applied, the compressor was accelerated to about 93 per cent synchronous speed of the motor, as indicated at *C*. Then to get the motor to a speed where it could pull into step, the field circuit was closed to the discharge resistance of 7½ times the value of the field-coil resistance. Under this condition the motor accelerated to about 97½ per cent speed. At this speed it was able to pull into step when the field switch was closed to the source of excitation. It is interesting to note that with this method of starting it was possible to bring the motor up to synchronous speed, with 95 lb. in the bypass before the discharge valves opened, in 55 sec. By this same scheme of starting it was possible to bring the motor up to synchronous speed with 30 lb. gage in the bypass in 25 sec. and with 40 lb. gage in the bypass in 35 sec. All these starting periods could have been reduced by rushing the closing of the bypass and the switching operations. Fig. 5 is very largely a schematic diagram rather than actual test points. However, it gives a clear idea of what happened during the different operations while bringing the motor up to speed.

A compressor of this type has recently been equipped with a bypass large enough so that the linear velocity of gas in the bypass is only 126 ft. per second and the pull-in torque required is only 10 per cent. This installation could be started from rest and completely synchronized in 15 seconds.

For comparison Fig. 6 is shown, giving the speed-torque curve of another compressor, which has a large enough bypass. It can be seen that the pull-in torque is less than 20 per cent. This particular machine did not have such good bearings and the starting torque was over 50 per cent.

This illustrates that the motor manufacturer must know about the compressors for which he is recommending motors. One make requires high pull-in and low starting torque; another make requires low pull-in but high starting torque. In general, if the velocity of the gas through the bypass is approximately 100 ft. per sec., the pull-in torque will be low.

A Meter for Recording Alkalinity of Boiler-Feed Water

By ROBERT C. ARTHUR* and EARL A. KEELER†

EXPERIMENTS undertaken to develop a means of properly controlling the quality of boiler-feed water have resulted in the development of an electrical recorder that gives a continuous record of the acid or alkaline conditions in the water

THE difficulties encountered in utilizing feed water having an acid content, for power-plant boilers, are well known to operating engineers. The resulting corrosion of boilers, valves, pumps and piping is frequently a source of considerable trouble and expense. For this reason the development of a satisfactory recording meter for measuring acidity and alkalinity of feed water was undertaken. The installation described in this article was conducted by the Leeds & Northrup Co. in co-operation with the Public Service Electric Co. of New Jersey, at the suggestion of the Babcock & Wilcox Co. Because of the troublesome feed-water conditions existing at the Perth Amboy plant of the Public Service Electric Co., that plant was selected for the experimental installation.

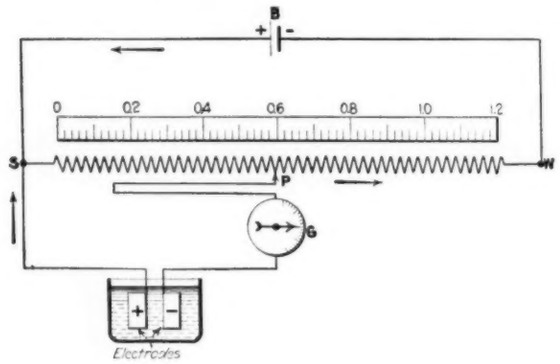


FIG. 1. DIAGRAM OF A POTENTIOMETER

It is recognized that the proper control of boiler-feed alkalinity will greatly decrease the corrosion of boiler steel and auxiliaries.[1] A slightly alkaline feed is usually preferable to an acid feed. Highly alkaline feed water should be avoided because of the large amounts of dissolved salts and the possibility of making the boiler steel brittle. It is necessary, therefore, to maintain the alkalinity of boiler feed within rather close limits in order that the best operating conditions may be maintained. The usual titration method of determining alkalinity is not sufficient for the purpose.

One of the latest theories of corrosion is that it depends on the hydrogen-ion concentration of the solution to which the metal is exposed. The hydrogen-ion concentration of a soluble, or concentration of atoms of hydrogen carrying positive charges of electricity, is a measure of the actual acidity or alkalinity of a solution and is the quantity recorded by the new device subsequently described. Titration methods measure what is known as total acidity or alkalinity and under some conditions may give entirely different results from the hydrogen-ion method, which indicates only that part of the acid that is effective in causing corrosion at any given instant. In the treatment of boiler-feed water to eliminate corrosion, it is necessary to measure the actual alkalinity or acidity.

There are two methods of determining the hydrogen-ion concentration or actual alkalinity of the feed. The first is known as the colorimetric method and depends upon the use of a graded series of color indicators. By observation of the color reaction of these indicator solutions, when added to samples of the feed, the actual alkalinity may be determined within reasonable limits. The color ranges for methyl red and phenolphthalein are given in Fig. 3. The method is, however, subject to personal errors of the observer and lighting conditions. It also possesses the disadvantage of requiring frequent sampling and observations to take care of fluctuations in alkalinity.

For these reasons the second, or electrometric, method is preferable. Two electrodes are immersed in a small bypassed flow of the feed water, and a recording potentiometer is used to record the voltage existing across these electrodes.

In Fig. 1 a simple diagram of a potentiometer is shown connected to electrodes immersed in an electrolyte, thus forming a simple galvanic cell or battery. The slide-wire resistance *SW* is connected across the terminals of the battery *B*, which results in the total voltage of the battery being distributed along the slide wire. By moving the sliding contact *P*, a variable portion of this voltage is available between points *S* and *P*.

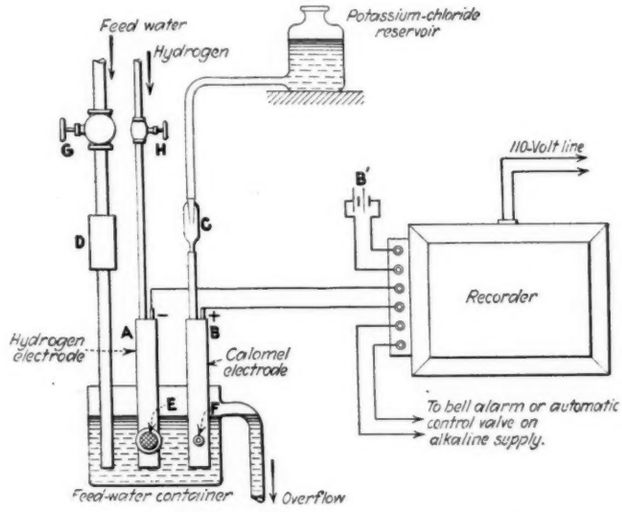


FIG. 2. DIAGRAM OF AN ALKALINITY METER

*Engineer of tests, Public Service Electric Co., Perth Amboy (N. J.) Station.

†Research Engineer, Leeds & Northrup Co.

[1]Pages 166-167, Section T5-21, 1921, Report of Prime Movers Committee, Technical National Section, National Electric Light Association.

The two electrodes are connected to points on the slide wires so that their polarity opposes the polarity of the battery *B*, as indicated in the figure. By adjustment of point *P* on the slide wire *SW*, an equal and opposite voltage can be secured that will exactly balance the voltage existing across the electrodes. Such a condition is obtained by moving slider *P* until no current flows through the galvanometer *G*, as evidenced by the deflection becoming zero. The potentiometer is then said to be balanced, and at that time no current flows through the electrodes of the cell being measured. In this feature the potentiometer method possesses an advantage over other methods. All other devices for measuring voltage require current flow between electrodes. For acidity or alkalinity measurement it is important to avoid passing current through the electrodes. A diagram of the equipment for measuring the acidity or alkalinity of boiler-feed water is shown in Fig. 2.

The recording potentiometer, in Figs. 2 and 6, automatically adjusts the position of the slider *P* on the

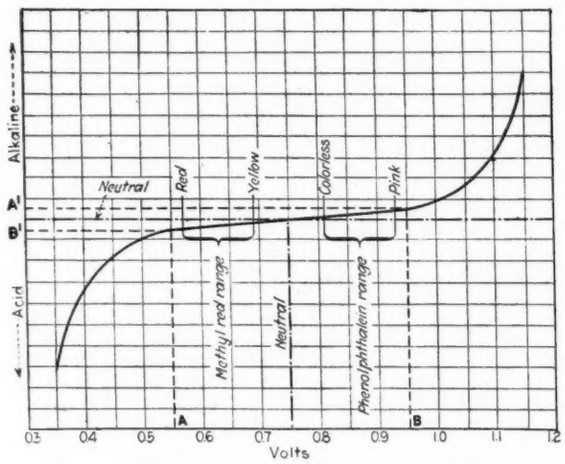


FIG. 3. RELATION BETWEEN ALKALINITY OF SOLUTION AND VOLTAGE ACROSS THE ELECTRODES

slide wire *SW*, Fig. 1, until the recorder galvanometer shows no deflection. The hydrogen electrode *A* and the calomel electrode *B*, Fig. 2, correspond to the electrodes in Fig. 1. Hydrogen gas is bubbled around the platinum gauze disc *E* of the hydrogen electrode *A*. A slow flow of tenth normal (0.75 per cent) potassium-chloride solution is permitted to flow through the calomel electrode *B* so as to prevent diffusion of the feed water into this electrode. A visible dropper *C* is used to observe the flow. The filter *D* is used to separate suspended matter from the feed water and thus avoid rapid contamination of the platinum-gauze electrode disc *E*. The electrode disc *E* is interchangeable and may be quickly removed by unscrewing a knurled head, and a clean disc substituted. Removal of the electrode disc for cleaning is recommended every two days, although satisfactory results have been secured from one disc over varying periods up to two weeks. Excepting for the renewal and cleaning of the electrode discs, very little attention to the equipment is required. Adjustment of water and hydrogen flow is made by means of valves *G* and *H*. A 100-cu.ft. tank of commercial hydrogen is used with a reducing valve. Such a tank will operate the equipment for about two months before requiring refilling. A pinch-cock or piece of capillary tubing in the potassium-chloride feed line is sufficient to throttle the flow of potassium chloride to about one drop every ten seconds.

The relationship between actual alkalinity of solution and the voltage across the electrodes is shown in the curve, Fig. 3. It will be noted that the greatest sensitivity to voltage change occurs around the neutral point

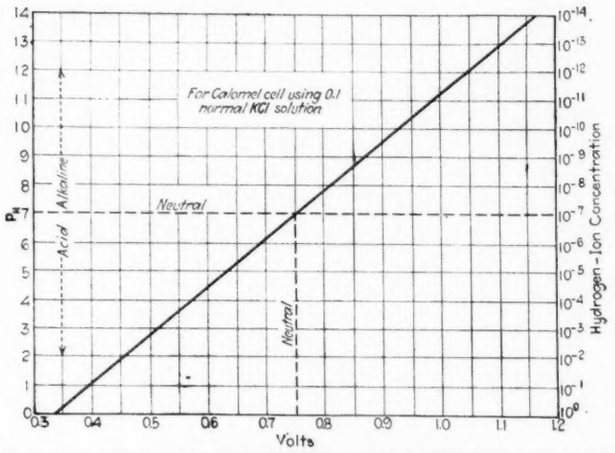


FIG. 4. RELATION BETWEEN HYDROGEN-ION CONCENTRATION, p_H VALUES AND VOLTAGE BETWEEN ELECTRODES

and that the method is particularly well adapted for measuring small acidities or alkalinities. For example, at the neutral point of the feed water there will be developed between the hydrogen and calomel electrodes 0.75 volt. The acid content to reduce the voltage from 0.75 to 0.55 or the alkaline content to increase the voltage from 0.75 to 0.95 is small in either case. These changes are indicated by *AB'* and *BA'* respectively. This wide range of voltage for small changes in the

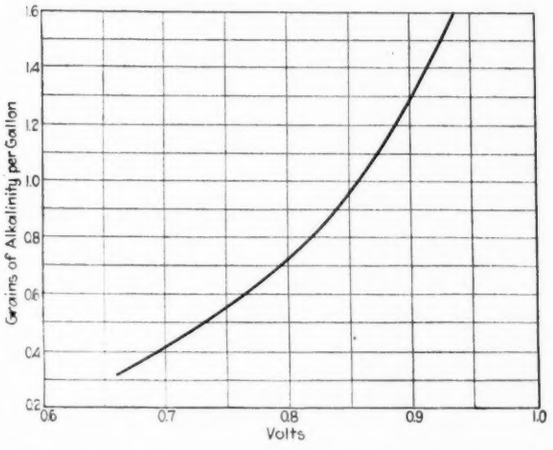


FIG. 5. RELATION BETWEEN GRAINS OF ALKALINITY PER GALLON AND VOLTS BETWEEN ELECTRODES

acid or alkaline content of the feed water make the meter very sensitive to small changes in the quality of the feed water. The peculiar shape of the curve is due to the fact that the voltage is a logarithmic function of the hydrogen-ion concentration.

Although it is customary to express actual acidity or alkalinity in terms of hydrogen-ion concentration, it is also the practice to express these in terms of the exponent of the concentration known as the p_H value

of the solution as in Fig. 4. For instance, a hydrogen-ion concentration of 10^{-7} (the equivalent of one part in 10,000,000) corresponding to a neutral solution, is expressed as a p_H of 7. A highly alkaline solution may have a hydrogen-ion concentration of 10^{-14} or a p_H value of 14, while a strongly acid solution may have a hydrogen-ion concentration of 10^{-1} and correspond to a p_H of 1. Fig. 4 shows the straight line relationship existing between voltage and p_H values for solutions.

The first installation of this equipment gave good results after minor alterations were made to permit better adjustment of water and hydrogen-gas flow. An automatic recording potentiometer was used to record the variations in alkalinity. It was noted that the record at times showed indications of excessive acidities. Upon investigation it was found that sudden increases of load on the turbines produced temporary conditions of excessive air content in the feed water. The reason for this is probably due to the rapidly increased demand for water from the surge tanks creating a temporary vacuum in the feed-water heater and entraining air with the condensed steam. The increased flow of

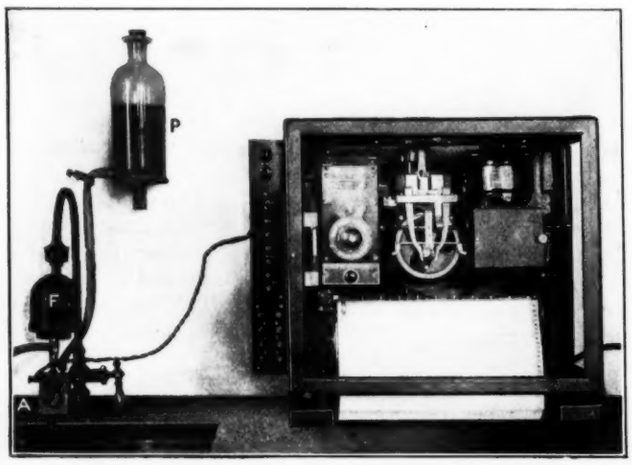


FIG. 6. COMPLETE EQUIPMENT FOR RECORDING ALKALINITY OF BOILER-FEED WATER

makeup water would also tend to raise the air content of the feed. The effect of this behavior was that the abnormal oxygen content of the feed water then made it difficult for the hydrogen flow to saturate properly the platinum electrode and resulted in a decrease of the observed voltage. It is important to note that while this behavior was not desirable from the viewpoint of alkalinity recording, it is indicative of the opportunities existing for the use of hydrogen electrodes for oxygen measurements in boiler feed.

To eliminate the effect of the oxygen variations, compressed air was fed to the hydrogen electrode instead of hydrogen. The behavior of the electrode was then essentially the same as that of an oxygen electrode. The characteristic voltage curve, Fig. 3, was practically the same excepting that the values of voltage observed were such that they fell outside the range of the recorder. By connecting a fixed voltage of 0.9 volt in series with the recorder and electrodes, the measurements were brought within the range of the recorder. Continued operation of the equipment showed that the operation of the electrode with air was reliable. In fact, the indications of the recorder seemed to be more reliable than chemical determinations of alkalinity made by unskilled operators. Fig. 5 shows the calibration curve as derived from a large number of voltage measurements and the corresponding alkalinity titrations.

To still further simplify the equipment, a new combined electrode was developed to take the place of the calomel and hydrogen electrodes. By passing the flow of feed water through an aspirator device open to the atmosphere, the water with its entrained air was directed against the electrode disc. Saturation of the electrode with air results, and the water flow completes the circuit between the calomel electrode and platinum-gauze electrode. Hydrogen gas may be fed into the aspirator suction tube instead of air if hydrogen-electrode measurements are desired. Fig. 6 shows the filter chamber *F* and the aspirator electrode connected to a water line. The recording potentiometer or acidity meter is on the right connected to the electrode terminals, and the potassium-chloride reservoir *P* is also shown.

The advantage of the acidity recorder lies in the convenience with which automatic control of alkalinity can be secured. By a simple system of relays and contacts a motor-operated valve can be made to control automatically the additions of alkaline. Such an equipment has been installed for the control of alkaline solution added to boiler-feed water. It is hoped that data as to performance of this equipment will soon be available for publication.

Heating of Synchronous Converters

The armature of a converter may be considered as carrying the difference between the direct current delivered as a generator and the alternating current received as a motor. The difference between these two currents varies in different armature coils, and therefore some coils are heated more than others. This objection, however, decreases as the number of phases of the alternating current increases. From this it is evident that a given armature will have more capacity running six-phase than it will running three-phase. If we consider a certain armature having a direct-current rating of 100 kw., its capacity as a converter will depend upon the number of phases.

Number of Phases	Safe Capacity in Kilowatts
1	85.2
3	133
4	162
6	193
12	219.5
Infinite	230

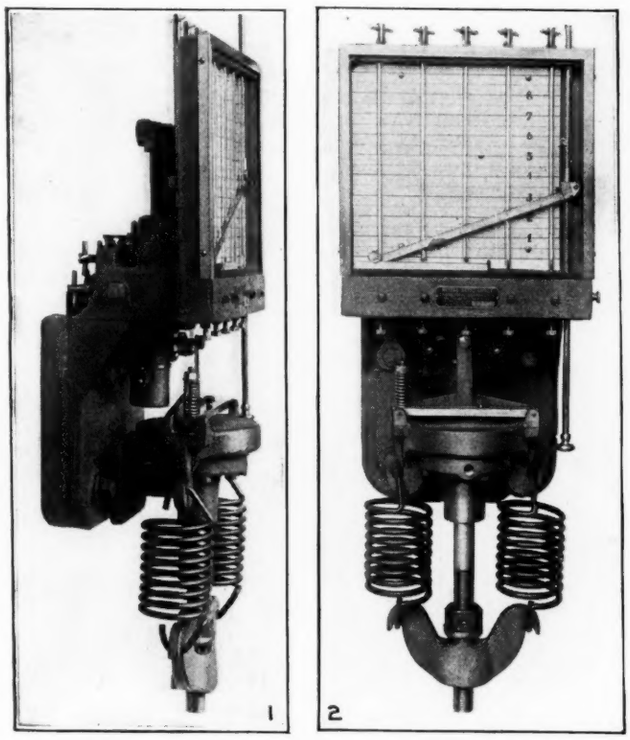
It will be seen that the capacity of a certain machine operating single-phase is 85 per cent of the direct-current rating. For this reason, single-phase converters are seldom used. Three-phase and six-phase converters are common, but twelve-phase are not because the increased expense of rigging more than offsets any gain in capacity.

S. W. Parr, of the University of Illinois, presents the following heat-value determinations on typical American woods: Oak, 8,550 B.t.u. per pound; pine, 8,836 B.t.u.; birch, 8,458 B.t.u. These heat values are calculated for the pure wood free from moisture. The quantity of moisture in thoroughly air-dried wood which is removable at 105 deg. C. is reported by Parr as follows: Oak, 8.35 per cent; pine, 8.88 per cent; birch, 10.18 per cent.

Centralized Combustion Control for Boilers

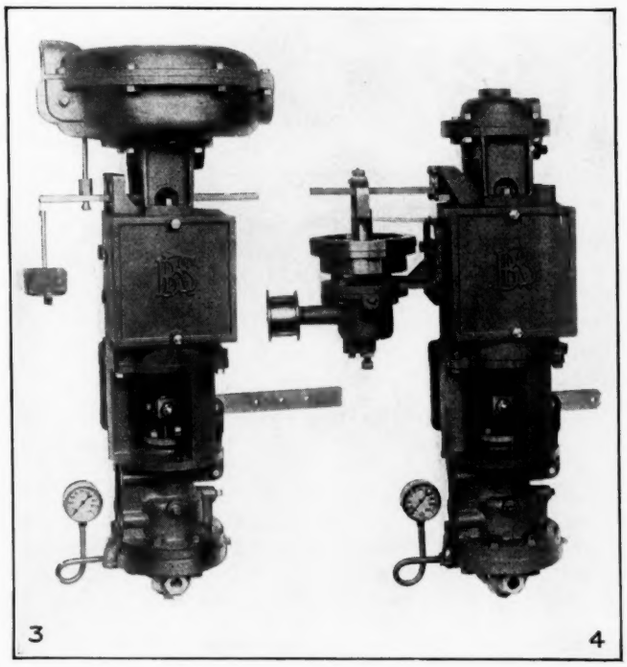
FROM the first introduction of the electrical generator its control has been localized at some central point in the plant. With steam equipment there are, even today in most plants, as many points of control as there are pieces of equipment. However, in some of the larger stations there is a tendency toward centralizing the control of the steam equipment, especially the boilers, and undoubtedly the next few years will see material advances made in this direction.

After a number of years of experimental work the Rateau-Battu-Smoot Co., of New York City, has developed a system of centralized combustion control that can be applied to one or a number of boilers, and their operation regulated automatically from a master con-



FIGS. 1 AND 2. SIDE AND FRONT VIEWS OF MASTER COMBUSTION CONTROLLER

troller. The object of the control is to maintain a character of combustion to give the best boiler efficiency for all conditions of load. If this is obtained at 15 per cent CO_2, then the master regulator is set for this value, and the control system supplies the proper amount of coal and air to the furnace for each boiler, to produce this condition. The system operates on a fixed variation in steam pressure between a maximum and a minimum value; for example, between 200 and 190 pounds. One of these equipments has been installed in Waterside Station No. 2 boiler plant of the New York Edison Co. and has been given extensive tests. The result of one of these tests, run on Feb. 16, 1922, is shown by the curves in Fig. 5. The boiler on which the tests were made is an old-type B. & W. having 6,386 sq.ft. of heating surface, made up of 294 four-inch tubes 18 ft. long, arranged 14 high and 21 wide, baffled for three passes.



FIGS. 3 AND 4. AUXILIARY REGULATORS

Fig. 3—Type of regulator used to control speed of forced-draft fan engine and dampers. Fig. 4—Type of regulator used to control speed of stoker engine.

The stokers are of the underfeed type, having a projected grate area of 94 sq.ft., with the top row of tuyeres 4 ft. 2 in., and the bottom row 5 ft. 1 in. from the first row of tubes. This setting is low compared to modern boiler settings.

This control equipment consists of one master controller designed to control any number of boilers; two auxiliary regulators for each boiler, to control the volume of air and draft; also an auxiliary regulator for each stoker and each forced-draft fan engine. Two views of the master controller are shown in Figs. 1 and 2. On the top are the mercury columns and chart, so that the boiler engineer can read the relation between stoker speed and air volume. Fig. 3 shows the type of regulator used on the forced-draft fan engine and to control the position of the dampers, and Fig. 4 the regulator for the stoker engine. The complete equipment is shown diagrammatically in Fig. 6. This apparatus is designed to supply a given amount of fuel and air to the boiler furnaces with each change of load on the

OPERATION of an equipment for automatically controlling a bank of boilers from a master controller is described in detail. The regulating system is designed to maintain a constant character of combustion at all loads on the boilers.

boilers. If the load is increased, the steam pressure decreases. This decrease in pressure on the master controller causes the auxiliary regulator to speed up the stoker engine to feed the proper amount of coal to the boiler to care for the load. The speed of the forced-draft fan is increased and the position of the dampers

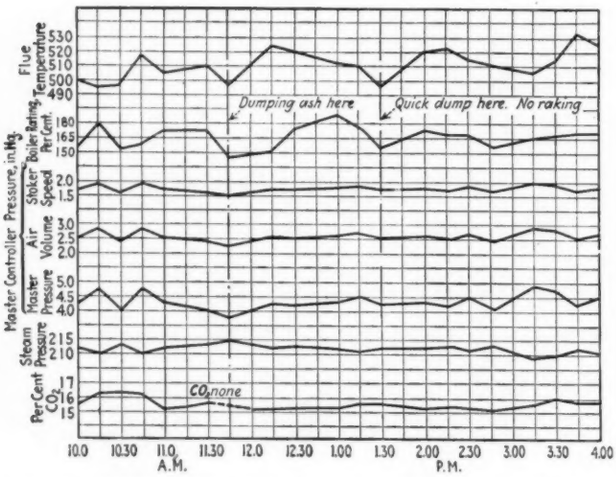


FIG. 5. CURVES SHOWING OPERATION OF COMBUSTION CONTROL SYSTEM, WITH READINGS AT MASTER CONTROLLER SHOWING RESPONSE TO STEAM-PRESSURE CHANGES

adjusted automatically, so that the necessary volume of air is supplied to burn the increased volume of coal to a predetermined per cent CO_2. If the load decreases on the boilers, the steam pressure increases. This increase in pressure is transmitted through the master controller to the auxiliary regulators and the volume of coal and air is decreased to meet the new condition.

On the master-control panel is a regulator R, Fig. 6, which is connected to the steam header and is therefore subjected to the full pressure of the boiler. The air for controlling the auxiliary regulators is controlled through the valve A. Balance is maintained between the steam pressure on diaphragm D in R and the air pressure in A, and the balance controls the conditions in the furnace. Boiler pressure under diaphragm D in regulator R works against the tension of spring S. An arm M connects diaphragm D with an inverted cup C over the air chamber in A. This cup allows air to leak out at all times, the amount of leakage determining the air pressure in A. This air pressure varies from practically zero at maximum steam pressure to about 2 lb. at minimum steam pressure. For every steam pressure between maximum and minimum there is a corresponding air pressure. As the steam pressure under D decreases, the air pressure under C increases, and vice versa, as is shown by the pressure curves, Fig. 5, for the master controller.

If the load is increased on the boiler, the steam pressure decreases. This will allow diaphragm D and yoke Y to drop a slight amount, this movement being very small. As yoke Y moves downward the movement is transmitted to cup C and decreases the flow of air to atmosphere, causing the pressure in A to build up and putting R in a state of equilibrium again. This increase in air pressure in A is transmitted to regulators on the stoker and forced-draft blower engines, causing them to speed up. This pressure is also transmitted to the regulators on the air and draft dampers and causes them to open an amount to supply the necessary air to burn the increased volume of coal supplied to the furnace. The small dashpot P, under cup C, prevents it chattering.

In Fig. 6 it will be noticed that all the regulators look alike below the diaphragm chambers at the top. The lower part is a standard equipment, with the top section made up to meet the different applications around the boiler. Therefore, the explanation for one will apply to all four applications. In Fig. 7 is shown a section through a regulator as applied to a forced-draft fan. Steam at boiler pressure is admitted to the chamber H at the bottom of the regulator and passes through the passage to the right into chamber C around the center of piston P. Steam also passes through the throttling orifice T and up into chamber C_1 under piston P. The pressure in chamber C_1 is controlled by the position of valve V, which allows steam to leak to atmosphere. The steam pressures on piston P, in conjunction with the other forces acting on the regulator, puts the whole system in balance for any given condition. Now assume, in Fig. 7, that an increase in load takes place on the boiler, as explained for Fig. 6. This increase in load causes the pressure above the loading diaphragm D_1 to increase and cause it to move downward. The downward movement of D_1 is transmitted to valve V through valve stem R. As valve V closes it causes

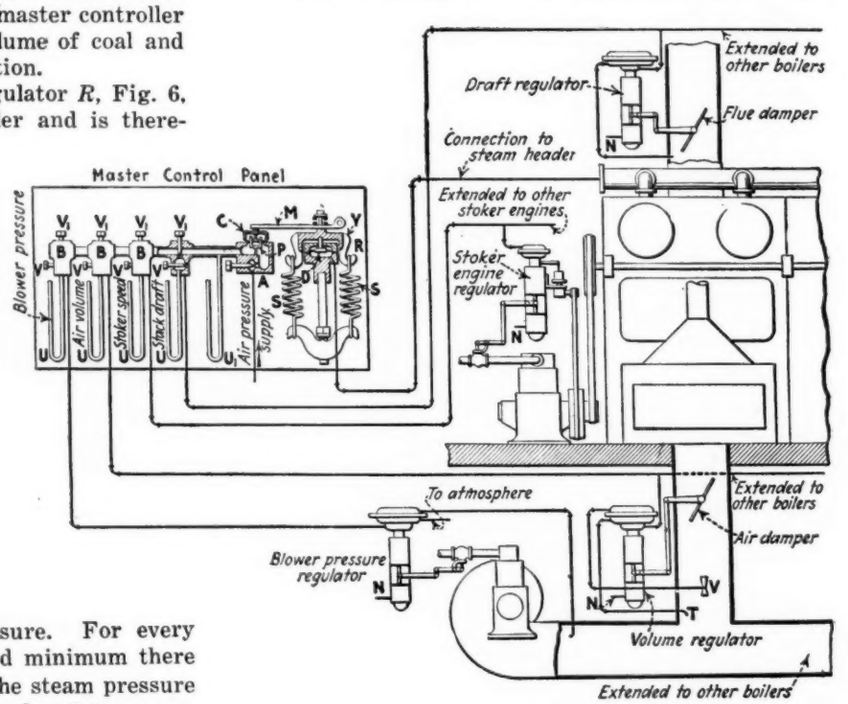


FIG. 6. SCHEMATIC DIAGRAM OF COMBUSTION-CONTROL SYSTEM AS APPLIED TO ONE BOILER

the pressure in chamber C_1 to increase and give piston P an upward motion, which will move lever L in a direction to open the throttle valve and admit more steam to the engine and increase the speed of the fan. The motion of P upward and the downward motion of D_1

are taken care of in dashpot B. This dashpot prevents any sudden change in the motion of the various parts and any tendency for the regulator to hunt.

When loading diaphragm D_1 was moved downward, it caused the left-hand end of arm A, which is supported at F on two thin metal strips, to move upward. This upward motion of A is transmitted to diaphragm D through arm A_1. When the fan speeds up, the pressure is increased in the air duct, and this pressure is transmitted to diaphragm D and causes D to tend to move downward and overcome the upward thrust of A_1 and again put the regulator in a state of balance. The parts of the regulator are so proportioned that every definite change in pressure on the loading diaphragm D_1 corresponding to a definite change in load on the boiler, causes a definite change in air pressure in the forced-draft duct. This change in air pressure, when transmitted to diaphragm D, puts the regulator in balance, after conditions have been adjusted to care for the load on the boiler.

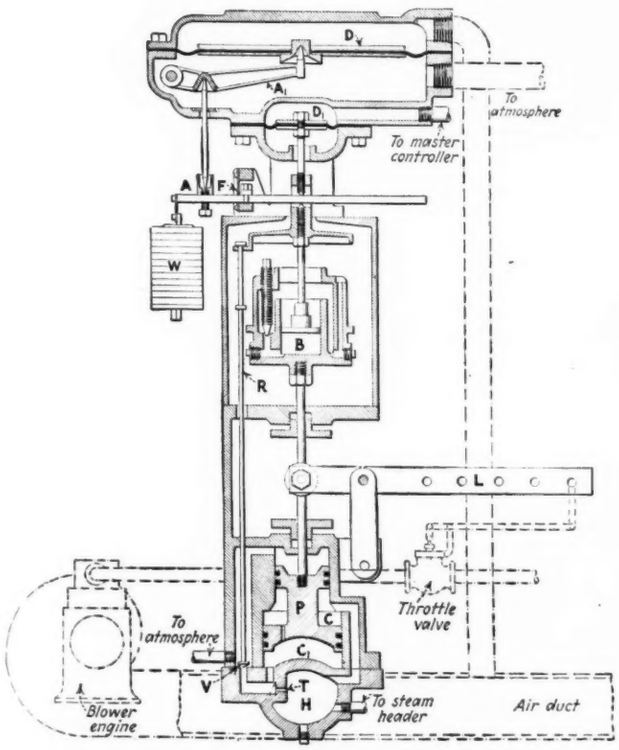


FIG. 7. SECTION THROUGH FORCED-DRAFT FAN ENGINE REGULATOR

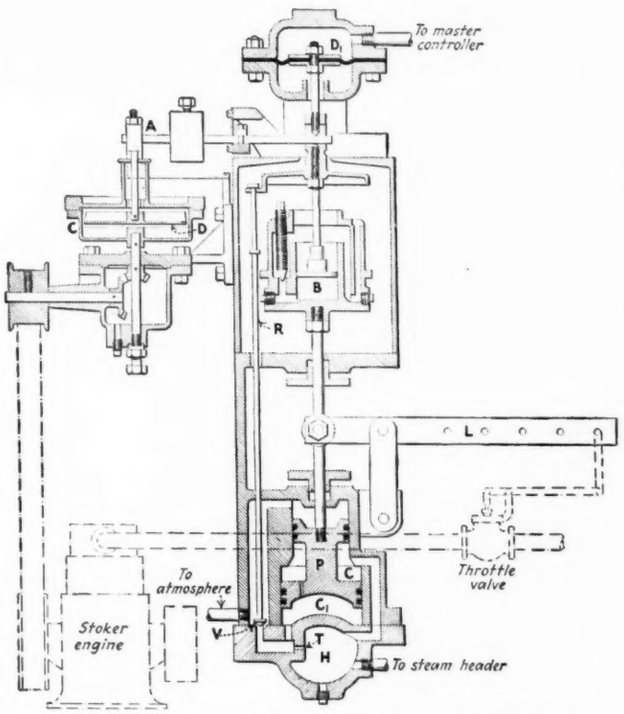


FIG. 8. SHOWING SECTION THROUGH STOKER ENGINE REGULATOR

On the stoker engine an oil-type governor is used in place of the flyball type. An oil container C, Fig. 8, is connected to the engine shaft through gears and a belt. In this container is a disc D with radial vanes on its top surface. This disc is connected to the regulator and is held stationary. When the air pressure is increased on diaphragm D_1, the stoker engine is caused to speed up, as explained for the forced-draft engine, and the left-hand end of arm A starts to move upward. When the engine speeds up, the speed of the oil container on the governor is increased, and oil is caused by centrifugal force to flow out from under D. This causes a reduction of pressure under the stationary disc, which increases the downward force on A to overcome the motion caused by the air pressure on D_1. The change in forces acting on D and D_1 again puts lever A and regulator in balance, when the stoker engine has reached a speed to supply an amount of coal to the furnace corresponding to the new load conditions on the boiler.

The volume regulator on the stoker air duct, Fig. 6, operates similarly to that on the forced-draft fan engine, as explained in Fig. 7. If the load increases on the boiler, the air pressure from the master controller is increased on the loading diaphragm of the volume regulator and causes it to operate and open the damper. Opening the damper, in conjunction with the increased pressure produced by the fan, causes the air to have an increased velocity and changes the pressure differential between the venturi tube V and the pitot tube T. This change in pressure acting on the control diaphragm puts the regulator in balance for the new load conditions. The balance is obtained at such a point that the correct amount of air will be supplied to the fuel to burn it to the per cent CO_2 set on the master regulator.

The increased volume of coal and air to the furnace, to take care of the increased load, increases the volume of gases up the stack. If the stack damper was not changed, the draft balance over the fire would be disturbed. This is taken care of by the draft regulator, Fig. 6. When the load increases on the boiler, the master regulator increases the pressure on the loading diaphragm of the draft regulator and causes it to operate to open the damper and increase the draft. This changes the pressure in the boiler uptake, which pressure is communicated to the control diaphragm on the regulator and puts the regulator in balance when the damper has taken a position to give balanced draft over the fire.

The speed of the stoker engine and forced-draft fan bears a definite relation to the steam pressure, increasing as the pressure decreases and decreasing as the pressure increases. However, the air pressure under the stokers is maintained by the damper regulators at a value that will supply the volume of air to the fire corresponding to the stoker speed, and consequently the amount of the coal delivered to the furnace. As the thickness of the fire increases, the resistance to the passage of air increases, which will tend to slow up the air flow.

A slight slowing up of the air flow will reduce the difference of pressure between venturi tube *V* and the pitot tube *T*, which change, acting on the regulator, opens the damper an amount to maintain the flow of air practically constant. On the other hand, if a hole blows in the fire, the velocity of the air in the duct increases and produces an increased difference in pressure between *V* and *T* and causes the regulator to close the damper until the volume of air going to the fire will correspond to the stoker speed. What has been said regarding a hole in the fire also applies to a fire that burns thin. In this case the resistance to the flow of air is reduced, and its increased velocity causes the regulator to adjust the damper to allow the proper amount of air to the furnace.

Adjustment for the relation between stoker speed, forced-draft-fan speed, air volume and draft are made by adjusting the valves *V* and V_1 on the master controller, Fig. 6. The air pressure on each regulator is indicated on the U-tubes *U* where the tube U_1 is calibrated for boiler rating. The tubes marked *U* may also be calibrated to indicate the quantities which they represent; namely, stoker speed, air volume, stack draft, blower pressure. The ratio of air volume to stoker speed may also be read directly from the diagonal scale, Fig. 2, this being a measure of the CO_2. Although the installation referred to in the foregoing has been applied to steam-engine driven stokers, the equipment may be used with chain-grate stokers, gas or powdered-fuel fired boilers.

Hopper Feed Added to CoKal Hand Stoker

To improve operating conditions and to increase the efficiency and capacity of its hand-operated stoker, the CoKal Stoker Corp., 341 East Ohio St., Chicago, has added recently a hopper feed, which eliminates hand firing and makes it possible to receive the coal directly from conveying equipment or overhead bunkers. The improvement also obviates the necessity of opening and closing firing doors, which disturbs combustion conditions by letting in excess air during the firing period. As the fires are self-cleaning, as explained in a previous article[1] on this stoker, there is no occasion to open the furnace front.

Under the outlet from the hopper, as shown in Fig. 1, hand-operated feeder gate blocks have been provided to force the coal into the furnace when and where required. These blocks serve three purposes—as valves to the hopper outlet, as coal pushers and as refractory seals to prevent the admission of air and the burning back of the coal into the hopper. They are moved forward and backward by means of the small hand lever. The number of blocks used depends on the width of the furnace. Under a 1,500-sq.ft. boiler it is usual to employ three. Fig. 2 shows a 3,000-sq.ft. boiler served by three stoker sections and four feeder gates.

Indirectly, one of the effects of the new arrangement is to increase the active surface of the stoker. In the usual case of firing on a hand stoker, if the fireman is

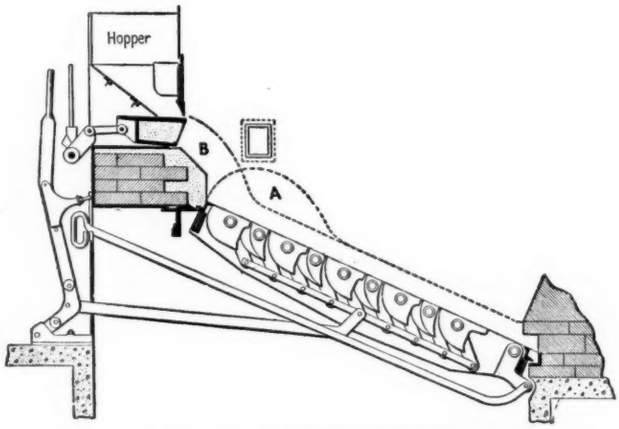


FIG. 1. SECTION THROUGH IMPROVED STOKER
The new feature is the hopper feed; note the feeder block, which is operated by the small hand lever.

not careful, he is likely to carry the pile of fresh coal farther back than is necessary, thus reducing the active incandescent area of the fuel bed. This will create a tendency for at least a part of the volatile matter to pass off unburned. The coking coal takes a contour similar to that indicated at *A* in Fig. 1.

With the hopper-feed stoker, however, the fresh coal from the hopper takes the outline indicated by *B*, so that

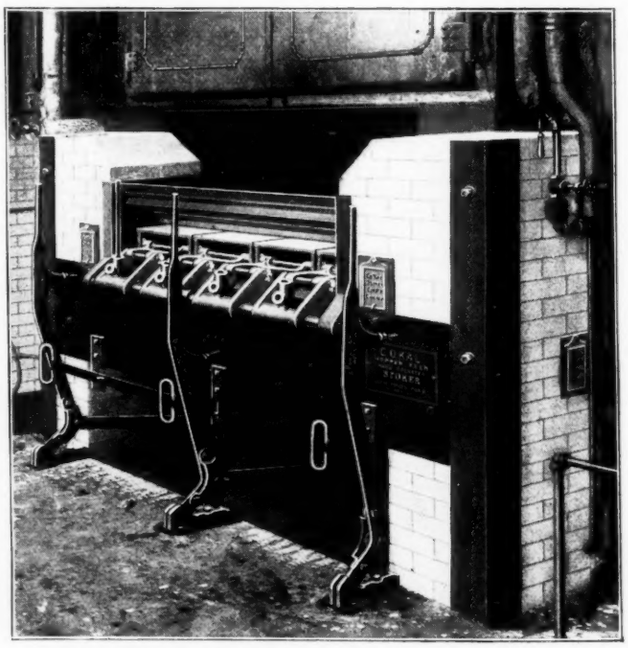
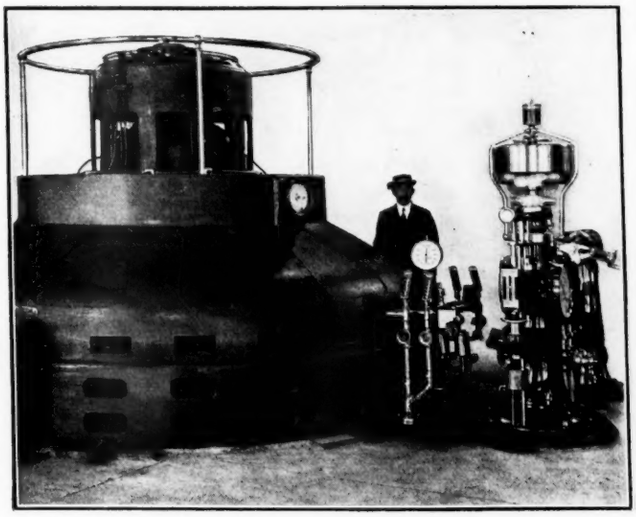


FIG. 2. INSTALLED UNDER 3,000-SQ.FT. BOILER
There are three stoker sections and four feeder gates.

practically the entire area of the stoker is active. The coking takes place over what was formerly the firing-door area, and the action is helped by the introduction of a 2-in. flat arch that is installed with the hopper-feed stoker.

[1]See *Power*, Dec. 17, 1918, page 877.

Selection of Auxiliaries for Hydro-Electric Power Stations



By F. H. ROGERS
Hydraulic Engineer, William Cramp & Sons Ship and Engine Building Company

CENTRAL Versus Individual Pumping Systems for Governor Fluid—Water Versus Oil as Governor Fluid—Lubrication Systems for Waterwheel Bearings—Separate Small Waterwheels for Auxiliary Power Supply

AUXILIARY equipment for the waterwheels in hydro-electric power stations consists primarily of the pumping system required for the governors, the lubrication system required for the bearings, and the small waterwheels for driving exciter units or pumps.

In a plant containing but a single unit, or even two units, the individual pumping system for the governors is naturally adopted, but where three or more units of any size are installed in the plant, the central pumping system is recommended as having many advantages over the individual system. The central pumping system usually consists of two or three motor-driven pumps located at one place in the power house. Where two pumps are furnished, they are designed of such capacity that one will take care of the requirements of all the units in the power station, the second pump being held as a spare. Where three pumps are selected, it is usual to design them so that two will take care of the entire power station and the third will be held as a spare. All the pumps discharge into a common pressure main extending the length of the power house and connected opposite each of the main units to the pressure accumulator tank. The discharge fluid from the governors is connected to a common return main extending the length of the power house, which discharges into the central sump tanks located close to the pumps.

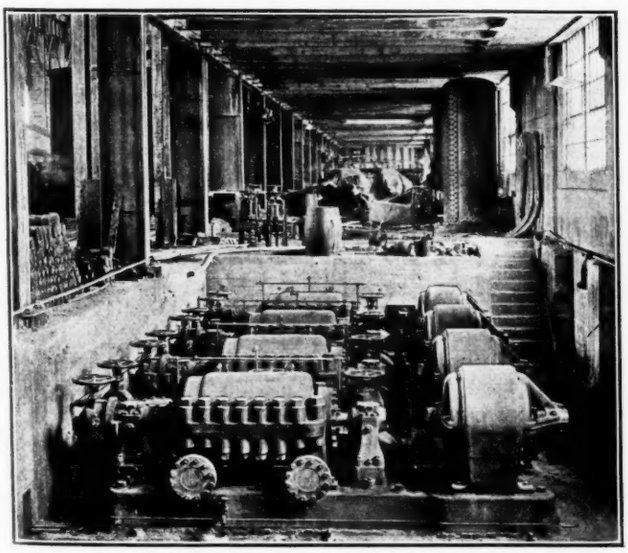


FIG. 1. FOUR MOTOR-DRIVEN SIX-STAGE CENTRIFUGAL GOVERNOR PUMPS IN CEDARS PLANT

Fig. 2 is a diagrammatic layout of the central pumping system for Cedars plant of the Montreal Light Heat and Power Consolidated, designed for a final installation of eighteen 10,800-hp. turbines and three 1,500-hp. exciter turbines. Water is used as governor fluid. Fig. 1 shows four motor-driven centrifugal pumps, each of 1,100 gal. per min. capacity in the Cedars plant. One of these pumps can take care of the governor requirements for the present installation of 12 main units and 3 exciter units, the remaining pumps being held as spares.

In the individual system it is usual to furnish one pump for each main unit, this pump being located close to the unit and having its own sump tank. In a large plant containing say ten main units, there would therefore be required for the individual system, ten pumps and ten sump tanks, whereas in the central system such a plant would require only two or three large pumps and one sump tank. The adoption, therefore, of a central system as compared with the individual system results in a reduction in the number of pumps and the concentration of these auxiliaries at one place in the power house, both of which advantages produce economy of operation and maintenance.

In the central system the capacity of each pump is considerably greater than in the case of the individual system, and this permits the adoption of centrifugal pumps instead of the rotary- or triplex-type pumps which are usually adopted for the individual system. Owing to the absence of gears or rubbing contact, the centrifugal pump is cheaper to maintain and is much quieter in operation than either the triplex or rotary type. In large plants requiring for the governor system from 1,200 to 1,500 gal. per min., this capacity can readily be supplied by a single centrifugal pump at a reasonable cost, whereas triplex or rotary pumps of such a

capacity would be cumbersome in size and expensive. For some years past the central pumping system has been used in a majority of plants containing three or more main units.

Water Versus Oil as Governor Fluid

The operating and maintenance expenses in a hydroelectric plant are usually low, but a large proportion of such expenses consists of the cost of oil used. In addition to the question of cost oil leakages from the governor system are objectionable from the viewpoint of cleanliness and the bad effect of oil on concrete. The use of water, therefore, as the governor fluid as compared with oil, has the evident advantages of cheapness and cleanliness. The use of water also permits governor pumps of the centrifugal type, which cannot be used for handling oil, owing to the churning effect river water is not suitable for the governor system, water may be obtained from springs near the plant.

Two general methods have been adopted for treating the water in order to avoid rusting or corrosion of the piping and valves. The first consists in adding to the water from 1 per cent to 1½ per cent of soluble oil. This is usually a light emulsion oil which mixes thoroughly with the water rather than floating on top. This small quantity of oil will give the water sufficient lubricating qualities and will apparently give to the piping and valves a light protecting covering. This method of treating the water has been used successfully in the large plants of the Niagara Falls Power Co., Niagara Falls, N. Y., and in the Montague City plant of the Turners Falls Power and Electric Co. in Massachusetts.

The second method is the treatment of the water with potassium bichromate. It is usual to add this salt to

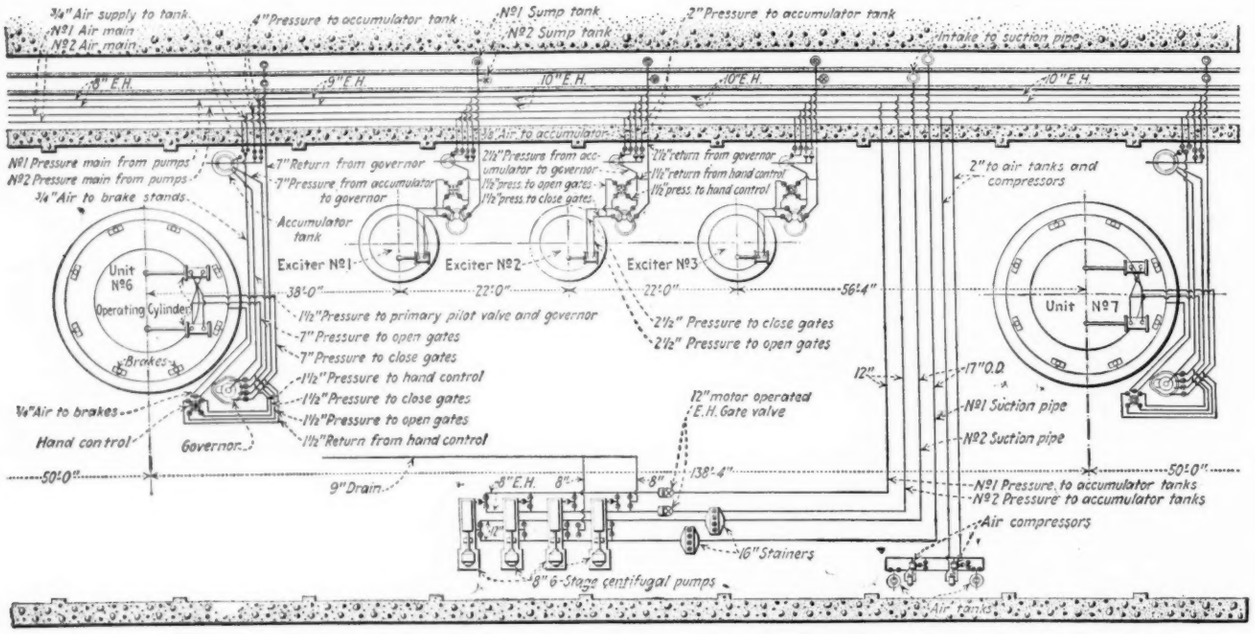


FIG. 2. DIAGRAMMATIC LAYOUT OF CENTRAL PUMPING SYSTEM IN CEDARS PLANT

and breaking down of the oil when handled in such pumps.

In the case of small plants where the quantity of fluid required for the governors is less than about 200 gal. per min., the centrifugal pump is not so frequently used, because of the low efficiency of high-pressure, low-capacity centrifugal pumps, and in such plants it is more usual to install rotary pumps.

When water is adopted as the governor fluid, it is of course necessary to secure clean water, free from acid, and it is usually found important to treat the water in order to prevent corrosive action on the steel piping and governor valves. In some plants the water for the governor system can be taken direct from the river and merely filtered to remove any sand or silt. It is then only necessary to add to this water some substance to prevent it having any corrosive action on the piping or governor valves. It is of course important in the case of each particular plant to make a careful chemical analysis of the water to be used so as to determine whether any acids are present and, if so, what chemical should be added to the water to counteract the action of such acids. In cases where the water in the governor system in the proportion by weights from 0.02 of 1 per cent to 0.06 of 1 per cent. The potassium bichromate does not apparently have any chemical action on the water, but produces on the inside of the piping and the governor valves a coating that protects these parts from corrosive action. This method of treating the water has been used for a number of years with entire success by the Shawinigan Water and Power Co. in its large plant at Shawinigan Falls, Quebec, Canada, the Montreal Light, Heat and Power Consolidated, in its Cedars plant, and the Hydro-Electric Power Commission of Ontario, in the plant at Nipigon, Camerons Falls. In the first two plants this method of treating the water has been in operation for eight or nine years, and during that time the water in the governor system has had absolutely no corrosive or other bad action on the governor piping or valves.

Lubrication Systems for Waterwheel Bearings

As a majority of the large waterwheels built during the last eight or ten years are of the vertical-shaft, single-runner type, only this type will be considered. The main guide bearing for such units is usually of the

water-lubricated lignum-vitæ type, and for such bearings the water supply can be taken direct from the turbine casing if the water is free from silt and sand.

It is usual to install a duplex strainer in the pipe line between the casing and the bearing to remove any foreign matter that may be carried in the water. Such strainers, however, will not remove fine sand or silt, and in cases where the water contains such sand or silt, it is always necessary to provide an independent water supply for these bearings, taken either from a filtration system in the power house or from some outside source of clear water. Fig. 3 is a section through a lignum-vitæ bearing and vertical-shaft turbine, showing the connections for lubricating water from the turbine casing, also a duplex strainer and flow indicator.

In the case of turbines operated under high heads, where it is important to maintain close clearances around the runner, it is often deemed advisable to use oil-lubricated babbitted bearings, and the lubrication system for such bearings is usually made independent. The circulation of oil through the bearing may be taken care of by a small rotary pump located in the turbine head cover, just below the bearing, and driven by belt from the main turbine shaft. This small pump elevates the oil which is passed through the bearing to its top, thus producing a constant circulation. Fig. 4 shows a section through a vertical-shaft turbine, with babbitted oil bearings and independent lubrication system. The belt-driven rotary pump produces constant circulation of oil through the bearing.

In some installations, however, central lubricating systems are installed, in which case all the oil passing through the turbine bearing and the generator bearings

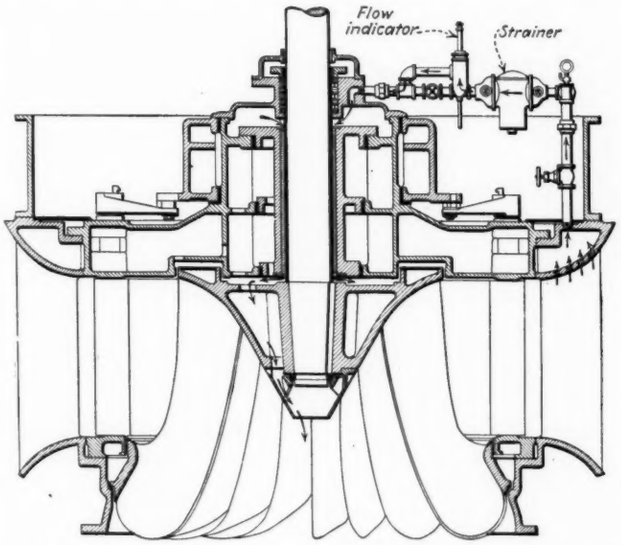


FIG. 3. SECTION THROUGH VERTICAL TURBINE AND LIGNUM-VITÆ BEARING LUBRICATED WITH WATER

is collected in a common sump and then pumped to a supply tank at the proper elevation, from which it flows by gravity through all the bearings. It is usual in such a system to provide a filter to remove any foreign materials that may get into the oil. For such a system a considerable amount of piping and several tanks are required, and it has been found that more dirt is liable to get into the oil than in the case of the individual, self-lubricating bearing, and for this reason there seems to be a tendency in recent years to eliminate the central lubricating system and to make each bearing independent. In some plants, where oil is used in the governor system, this system has been interconnected with the bearing-lubricating system, but such an arrangement has a number of serious objections.

Small Waterwheels for Auxiliary Power Supply

In a number of plants separate small waterwheels have been installed directly connected to generators, for supplying auxiliary power required in the station,

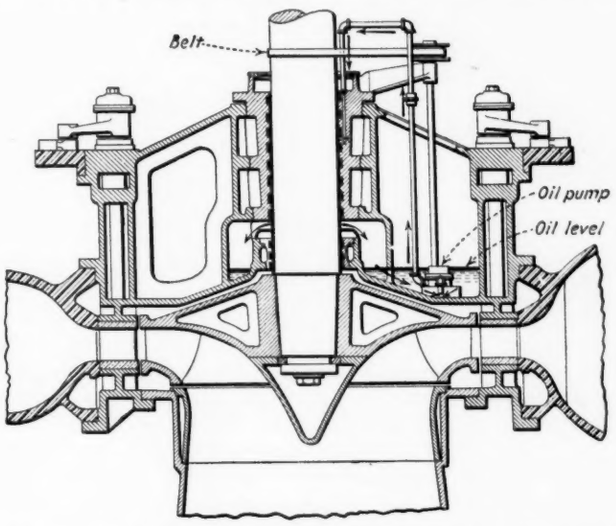


FIG. 4. SECTION THROUGH VERTICAL-SHAFT TURBINE AND BABBITTED-BEARING LUBRICATED WITH OIL

such as the excitation and operation of governor pumps, water-supply pumps, etc. In other stations these small waterwheels are omitted and the exciter units are directly connected to the top of the main unit shafts.

In the more or less isolated plants that cannot be sure of an outside source of electrical power at all times, the separate waterwheel-driven units should undoubtedly be installed. Where a number of plants, however, are electrically interconnected, there is not so much reason for the separate waterwheel-driven exciter unit. Another point to be considered is the danger of electrical disturbances due to storms or short-circuits, which might entirely cut off a given plant from other stations. In such contingencies the separate waterwheel-driven exciter is of considerable advantage. In a number of the most modern plants of large size, it is customary to install small turbines connected to alternators, known as service units, which supply the power not only for general station uses, but also for operating the rotary converters or motor-generator sets for excitation current. The headpiece shows one of the hydro-electric service units in the Cedars plant. Three of these units are installed, each consisting of a 1,500-hp. turbine directly connected to an alternating-current generator and furnish power directly to motor-driven auxiliaries and rotary converters.

Waterwheel-driven pumps have been installed in connection with the governor system in some plants, so that in case of trouble on the electrical end, it will be possible to maintain the governor pressure and thus keep control of the units by means of the independent waterwheel-driven pump. Such an independent unit is a considerable advantage in isolated plants subject to electrical disturbances and in first starting up such plants.

Boiler-Room Performance at Colfax*

Describes in detail the operation of the boiler plant at the Colfax Station of the Duquesne Light Co. There are included sample analyses of fuel, and ash, temperature and CO_2 records, temperature and velocity of flue gas, boiler-test data and a six months' summary of boiler performance.

BY C. W. E. CLARKE
Power Engineer, Dwight P. Robinson Company, Inc.

COLFAX station[1] of the Duquesne Light Co., at Cheswick, Pa., contains one three-element compound 60,000-kw. Westinghouse turbine, and an additional similar machine will be installed this summer. Present plans contemplate an ultimate capacity of 360,000 kw. The boiler plant contains seven boilers, 18 tubes high by 51 wide, each containing 20,867 sq.ft. of heating surface; four additional boilers, 20 tubes high by 51 wide, each containing 22,914 sq.ft. of heating surface, are being added. The stokers are of the Westinghouse underfeed type with 17 retorts of 20 tuyeres each, the projected grate area of each being approximately 403 sq.ft.

A representative sample of each day's coal is secured by taking individual samples of about 75 lb. from each carload as the cars are dumped. The whole day's samples are then run through an automatic crushing and sampling machine which extracts a 3 to 4 per cent sample, amounting at the present time to about 40 lb. To obtain samples of coal as fired, a sample of about 1,000 lb. is also taken from the stoker hoppers at 7 a.m. daily. This sample is used as a basis for the daily heat-balance computations.

*Abstract of a paper presented at the spring meeting of the American Society of Mechanical Engineers at Atlanta, May 8 to 11.

[1]For a detailed description of this station see *Power*, April 5, May 3-24, 1921.

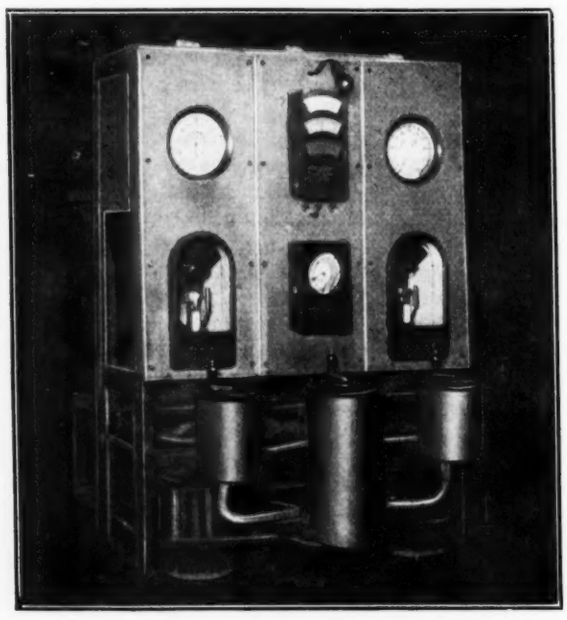


FIG. 1. BOILER INSTRUMENT BOARD

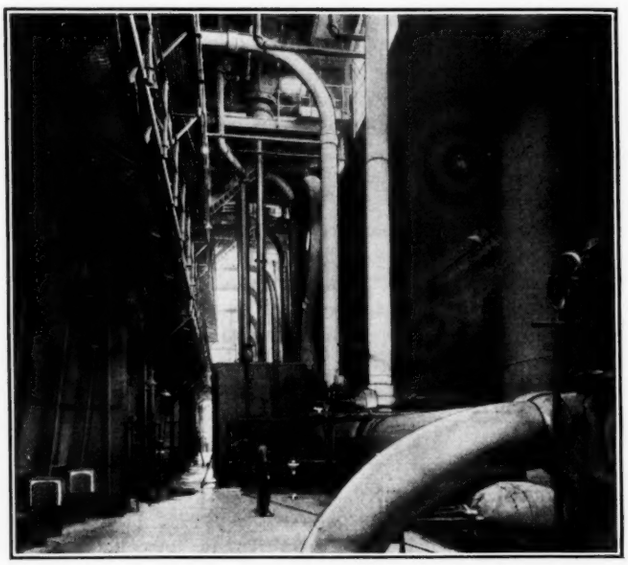


FIG. 2. REAR OF BOILERS SHOWING HIGH PRESSURE STEAM PIPING

Table I shows the average of a number of proximate analyses of the fuel.

TABLE I. COAL ANALYSES

	As Unloaded	As Fired
No. of samples	25	30
Moisture, per cent	2.9	4.1
Volatile matter, per cent	34.5	34.1
Fixed carbon, per cent	53.0	52.5
Ash, per cent	9.6	9.3
Total, per cent	100.0	100.0
Sulphur, per cent	1.0	1.1
Calorific value, B.t.u. per lb.	13,351	13,237

The difference in moisture between the coal as unloaded and as fired is due to the addition of water at the crushers to keep down the dust and as an aid to combustion.

Distribution of the fuel to the stoker hoppers is by means of two weighing larries. After the weighing hopper is filled from a bunker chute, the operator balances the scales and prints the gross weight on a coal ticket by inserting the ticket in a slot on the beam weight and pressing a lever. After distributing the proper quantity of coal to a stoker, he prints the tare weight on the same ticket. He then subtracts the tare from the gross and enters the net weight of coal on his log sheet, charging it to the proper boiler and indicating the time.

TABLE II. SUMMARY OF FUSION TESTS OF COAL AS FIRED

Date of Sample	Per Cent Ash	Softening Temp., Deg. F.	Softening Interval, Deg. F.	Flowing Interval, Deg. F.
July 19, 1921	9.96	2,462	187	112
July 29, 1921	7.40	2,426	71	90
August 5, 1921	9.96	2,534	64	72
Sept. 1, 1921	10.32	2,210	36	180

Definitions

Softening Temperature: The temperature at which the cone of ash has fused down to a spherical lump.

Softening Interval: The difference between the softening temperature and the temperature at which the first rounding or bending of the apex of the cone takes place.

Flowing Interval: The difference between the softening temperature and the temperature at which the ash has reached a fluid condition as shown by spreading out over the base in a flat layer.

The stoker operator is guided entirely by observation of the fires and of the windbox pressure. The forced-draft fan speed and consequent windbox pressure are

automatically controlled by variations of the steam pressure in the main header. Windbox pressure is for this reason somewhat of an indication of load condition. The pressure over the fire is maintained at from 0 to minus 0.1 in. of water by means of balanced-draft damper controllers.

Over the center of the firing aisle a master gage, load indicator and clock are located. The master gage indicates main-header steam pressure and has a 24-in. face. The main-unit load is indicated in thousands of kilowatts by means of changeable, illuminated numerals which are controlled by the switchboard operator in the control room. Two more instruments are being added to this board, one to indicate the pressure in the forced-draft duct, the other to indicate the pressure in the boiler-feed header.

Each boiler is provided with an individual instrument and control board shown in Fig. 1. At the top are two pressure gages connected to either end of the boiler drum, and between them is a three-in-one draft gage which indicates the pressure in the windbox, over the fire and in the boiler uptake. Below the draft gage is a combined CO_2 and furnace-pressure recorder.

When this installation was first put in operation,

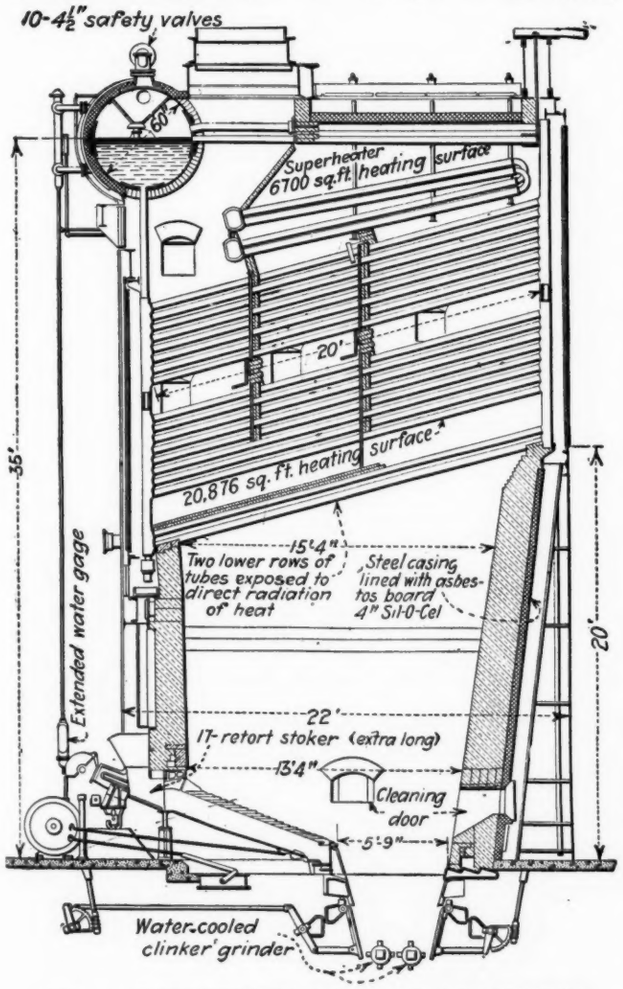


FIG. 3. CROSS-SECTION OF BOILER AND SETTING

some difficulty was encountered with clinkering. After considerable experimenting it was definitely determined that this was due in part to periods when there was pressure over the fires and in part to improper water distribution in the clinker pits. Particular care is now taken to maintain a furnace pressure below atmosphere at all times, and the water distribution has been improved as described below, with the result that clinker trouble has been practically eliminated.

Some trouble was at first experienced due to burning out of the lower front feed wedges. This trouble has

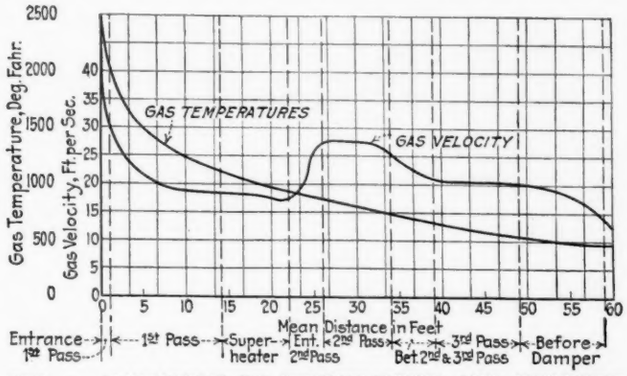


FIG. 4. VARIATION OF TEMPERATURE AND VELOCITY OF FLUE GAS THROUGHOUT THE BOILER

been largely eliminated by allowing air to blow through from the windbox, thus keeping the wedges cool.

The stokers are provided with double-roll clinker grinders, divided in the center, with the rolls turning toward each other. The two halves are driven by separate motors, separately regulated, giving individual control over the two halves of the grinder. The rolls are driven through reciprocating pawls and ratchets which may be disengaged on either roll. It has not been found desirable to operate the rolls continuously. Under normal operating conditions the rear rolls are operated rarely; the front rolls are run for periods of from two to five minutes in every twenty minutes, this meaning from six to eight revolutions in one hour. Grinder operation is governed entirely by observation of the ashpit.

To prevent the formation of clinker masses in the ashpit and to cool the clinker rolls, water is introduced above the rolls. At first this was done through cast-iron spray heads about eighteen inches high, which were mounted one on each of the five grinder-roll bearings. These heads sprayed water horizontally in all directions from their tops. There were also horizontal spray pipes, located below and parallel to the clinker rolls, which sprayed water up against the rolls for cooling purposes. It was found that though this served as a satisfactory cooling arrangement, the spray heads had a tendency to hold up the clinker masses and prevent their entering the grinder. Low, wedge-shaped bearing caps which sprayed water horizontally were substituted for the spray heads. These caps did not hold up the clinker and it could be ground out, but the grinding out of large clinker masses placed severe duty on the grinders. Neither of the foregoing arrangements put water high enough in the ashpit to prevent the formation of hard clinker. Finally, new upper-grate-box tops having a down-turned projecting lip were installed. Under this lip was placed a horizontal spray pipe perforated with quarter-inch holes six inches apart. This pipe introduces the water high up in the ashpit and quite effectually prevents the formation of hard clinker masses. The introduction of water high up in the ashpit tends to quench the ashes before combustion is as complete as could be desired, thus increasing the amount of combustible in the ash.

The brick lining of the ash hoppers is standing up very well after eighteen months of operation, no repairs having as yet been required.

A sample of ash from each boiler is taken every day. A gross quantity of about 400 lb. is taken from the total 24-hour dump from each boiler, the sample being taken from six different points in the pile, at a depth of about three feet below the surface. The whole sample is then hand-crushed and quartered until about three pounds remain, which is sealed in a container and sent to the laboratory to be analyzed for combustible.

Fig. 3 is a cross-section of the boiler and setting. It will be noted that the combustion space is large. The present settings contain 0.345 cu.ft. of combustion space per square foot of heating surface, and those to be installed this summer will be the same.

Each boiler has two water columns with high- and low-water alarm whistles. When one of these alarms sounds, the operator examines the feed regulators for possible sticking and, if necessary, cuts it out and uses hand control until repairs can be made. If the regulator is found to be all right, he checks up the feed pressure and, if necessary, starts another pump or puts on the auxiliary feed. Extended water columns, which can be read at the operating-floor level, were installed, but because of improper design could not be depended upon. These columns have been modified and are being installed again.

Furnace temperatures vary from 2,500 to 2,800 deg. F.; at the top of the first pass this approximates 1,000 deg. F., between the second and third passes it is 530 deg. F., and the exit-gas temperature varies from 450 to 480, usually being about 470 deg. F. Fig. 4 is a chart showing the temperature range and gas velocities

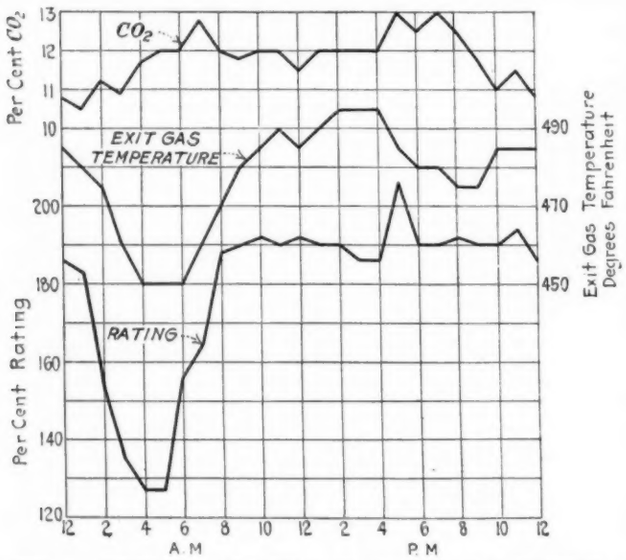


FIG. 5. HOURLY VARIATION IN RATING GAS TEMPERATURE AND CO_2 FOR TYPICAL 24-HR. DAY

through the boiler. Fig. 5 shows hourly variation in rating, gas temperature and CO_2 for typical 24-hour day.

Slagging on the boiler tubes is slight and has never been sufficient to cause trouble. The use of distilled makeup water eliminates trouble from scale and consequent tube renewals. The total commercial operation of the seven boilers now installed has been approximately 39,922 boiler-hours up to Feb. 1, an average of 5,703 hours per boiler, and but two tubes have been replaced. Fig. 6 shows the individual efficiency for all boilers from July, 1921, to February, 1922.

Each boiler is equipped with eighteen soot-blower elements, nine on each side. Trouble was experienced from warping of the elements apparently due to insufficient drainage. The drip system was altered so as to

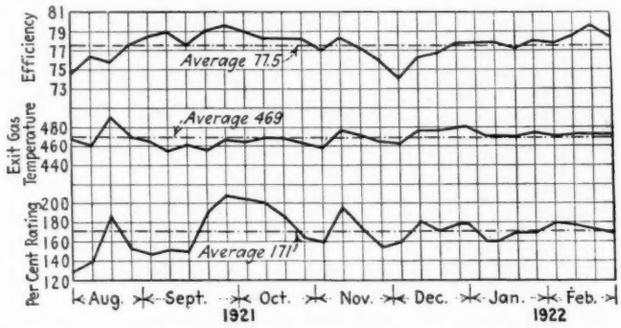


FIG. 6. AVERAGE WEEKLY BOILER PERFORMANCE FOR ALL BOILERS

The points on this curve are the weighted averages of the average weekly efficiencies for the individual boilers, hence the variations at some points.

carry this water off more positively and this sort of trouble was eliminated. Future installations will be modified so that no valves will be required on the individual soot blower leads. This will permit easy draining of accumulated water and will require but a single master valve on each side of the boiler. Soot blowers are operated three times a day with the dampers opened wide.

The regular procedure for taking a boiler off the line is as follows: When the boiler and setting are cool enough, the water is drawn out of the boiler through the blowoff lines. A large tank is provided into which the water from the boilers may be run and, after settling, pumped to the main storage tank or returned to the boiler. The present practice is to waste the water when emptying boilers. It has been found unnecessary to blow down at all between cleanings, and wasting this water is a precaution against the accumulation of impurities in the system. If a boiler has to be emptied after a short run, the water is returned to the system by means of the tank and pumps previously mentioned. When the boiler is empty, all valves are locked and posted with danger signs.

A certain number of tube caps are then removed, and the tubes inspected. A system is followed in tube inspection so that a new lot of tubes are covered each time a boiler is open.

When putting the boiler in service, a slow fire is usually maintained and the boiler heated up gradually, so that twelve to fourteen hours is required before the boiler can be put on the line. In an emergency a boiler can be put on three hours after the fire is started. Full efficiency is not reached until from four to seven days after the boiler is put on the line.

The formation of clinker on the furnace walls is prevented by air cooling blocks being used. These blocks did not altogether prevent clinkering on the side walls, and side-wall tuyeres have been installed. These have practically eliminated all clinkering on the side walls. Special tuyere-type, ram-box tops which blow air in directly over the retorts prevent clinkering and scoring on the front wall.

The superheaters are over the tube banks between

the first and the second pass. Considerable trouble has been experienced because of insufficient superheat. The normal superheat should be 180 deg., but 145 deg. has seldom been exceeded. The boilers to be installed this summer will have the superheaters located above the sixth row of tubes, and with this arrangement no trouble from deficient superheat is anticipated.

Ordinarily, no control of the stoker air other than that provided by the automatic forced-draft-fan speed control is used, although individual windbox dampers are provided that may be used in case of emergency.

Makeup water is provided by two evaporators of the double-effect dry-tube type. Water from the evaporators is pumped directly to the head tanks above the barometric condensers which serve as feed-water heaters. The evaporators have in general given satisfactory service, although some trouble was experienced due in part to improper design of some features and in part to lack of experience with the particular water being evaporated. The evaporator effects are reversed every four hours, thus minimizing scale formation.

Water qualities throughout the cycle are closely watched. A multiple-point indicating conductivity meter with cells located at various points is used to observe the water purity continuously. This instrument immediately indicates leakage of circulating water into the condenser and permits a close check in the quality of the distillate from the evaporators. No condenser leakage has as yet been detected, but much useful information on the performance of the evaporators has been obtained.

It has been found that dissolved oxygen in the feed water tends to pit the boiler drums. It has also been determined that this pitting takes place during banked periods, there being practically none when the boiler is active. In order to decrease the quantity of dissolved oxygen to the lowest possible point, all parts of the feed cycle are effectually sealed against air. The feed temperature is maintained at 205 deg. or higher to drive out the entrained air.

Further experiments are being carried on to determine whether a lower feed temperature with a higher vacuum in the barometric condenser will improve this condition.

Table III is a summary of boiler-room operations of six months, August to January inclusive.

TABLE III. SIX MONTHS' SUMMARY OF BOILER DATA, COLFAX POWER STATION

August, 1921, to January, 1922, Inclusive

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Average
Total active service, hrs..	2,782	2,493	2,474	2,361	4,038	2,894	2,840
Evaporation per lb. of coal	9.06	9.46	9.22	9.17	9.07	8.73	9.10
Av. feed temp., deg. F....	208	210	203	204	193	204	204
Av. superheat, deg. F....	124	120	127	127	132	136	128
Av. B.t.u. in coal per lb..	13,093	13,180	13,159	13,198	13,283	13,177	13,182
Av. efficiency, per cent..	76.4	78.9	78.0	77.2	76.8	77.6	77.5
Av. rating, per cent.....	154	167	187	167	176	168	170
Av. exit gas temp., deg. F	466	460	465	467	478	471	468
Av. CO_2 per cent.....	9.2	9.3	9.6	10.3	11.2	11.1	10.1

Effect of High Temperatures on Lubricating Oil in Circulating Systems

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

THE oil in a circulatory system of any kind is continually being exposed to heat. Each part of the oil has a chance to cool off somewhat after it leaves the bearing and becomes hot again when it goes through the bearing.

Heat causes oil to evaporate, the rate of evaporation varying with the temperature, other things being equal. Oil is a mixture of hydrocarbons each of which boils at a different temperature. Those that have the lowest boiling points also have the greatest rate of evaporation when subjected to temperatures below their boiling points.

When new oil is placed in a circulatory oiling system, the heat will cause a portion of it to evaporate even at the normal operating temperature. The part that evaporates will consist of those hydrocarbons having the lowest boiling points. This means that after a time the oil remaining in the system will have a higher boiling point, a higher flash and fire, a heavier gravity and a greater viscosity than the fresh oil. We find that such is actually the case and is quite pronounced when the oiling system is so well constructed that very little loss through leakage occurs, requiring practically no makeup oil.

The increased boiling, flash and fire points are not disadvantageous, because as the boiling point increases the rate of evaporation decreases, and these physical changes will take place at a decreasing rate. However, the increase in viscosity is sometimes quite a disadvantage on account of the increased frictional losses within the bearings and the slower rate of separation from moisture which might get into the system. The addition of fresh oil to make up for evaporation losses, while it decreases the viscosity temporarily, also adds to the system a further quantity of heavy hydrocarbons, and the viscosity gradually increases.

The viscosity of such a circulating system may be kept down to the desired point by occasionally removing a part of the oil and replacing it with fresh, or by adding as makeup oil one of a lighter viscosity than that in the system. The latter method, while temporarily increasing the rate of evaporation, is probably more economical in the long run than wholly removing a portion of the old and replacing it with a fresh charge of oil of the same general character.

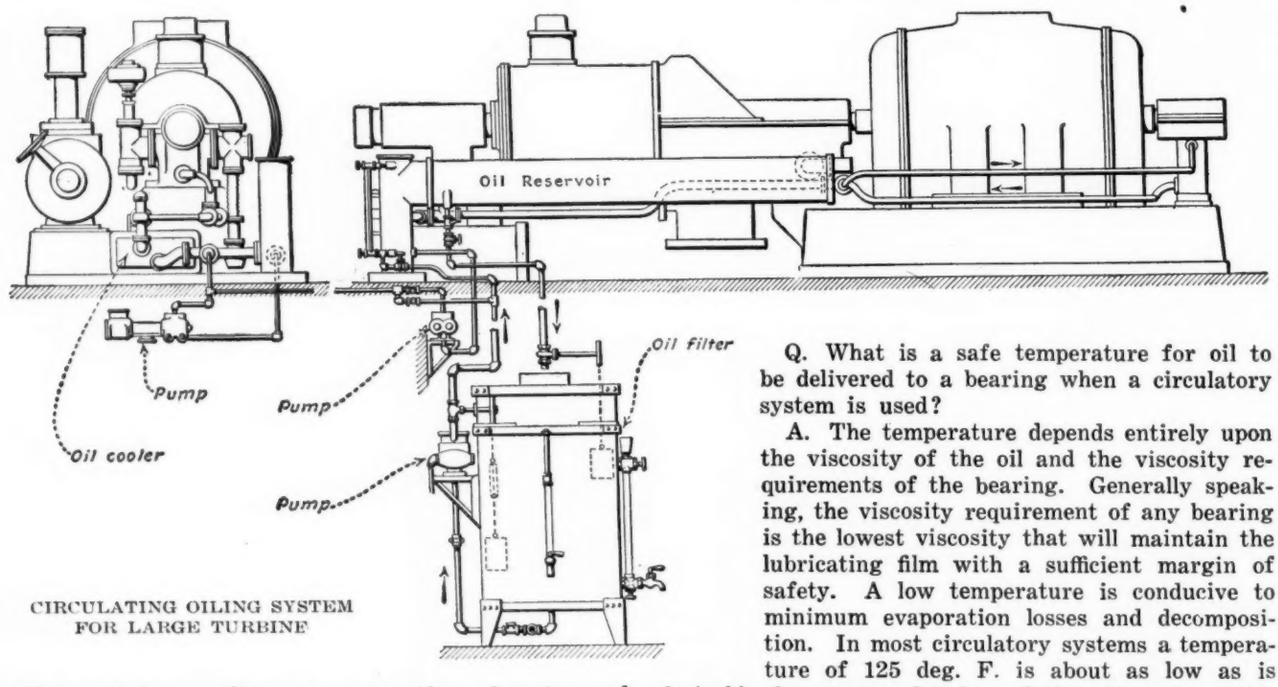
This natural evaporation of the oil makes it necessary to select for use in such a circulating system an oil that has been properly refined so as to eliminate any unnecessarily large percentage of hydrocarbons which quickly evaporate from the system.

High temperatures are conducive to chemical reaction, so that if there is any tendency of the oil to decompose it will do so more rapidly at high temperatures than at low. Oxidation and carbonization are increased when high temperatures exist in the system. For instance, in some engine rooms steam or electric heaters

are used in the winter to warm the oil so that it will flow properly to the bearings. If the circulation of the oil around the heaters is sluggish, the portion immediately next to the hot heater will carbonize, and when the carbon is carried away by the circulation of the oil it will quite likely deposit in some part of the system, causing trouble. When considered from this angle, a high temperature anywhere in a circulatory system is a bad thing for the oil, increasing the loss from evaporation and decomposition.

On the other hand very low oil and bearing temperatures are just as bad because they increase the viscosity of the oil, preventing proper separation of moisture and foreign material which may collect in the system. If the bearings are cooled abnormally by a large quantity of cold circulating water, the viscosity of the oil in the bearing clearance will be increased and the total horsepower required to overcome the friction will be increased, even though the actual bearing temperature may be quite low.

Evidently, then, the temperature of the oil should be neither too high nor too low, but should be properly adjusted to prevent excessive evaporation and decomposition and to permit proper separation of water and foreign matter from the oil.



CIRCULATING OILING SYSTEM FOR LARGE TURBINE

Whether a high temperature in the bearing itself is undesirable, depends a good deal upon the cause of the heat. If it is caused solely by frictional resistance due to insufficient lubrication, it should be reduced by removing the cause of the trouble. On the other hand, if the high bearing temperature is caused by conducted heat from the casing of a steam turbine for instance, it is not indicative of lost power, and except for its deteriorating effect on the oil, is not particularly dangerous, so long as it does not rise above the softening point of the bearing metal. Many steam-turbine bearings normally run at temperatures of 175 to 190 deg. F. without any trouble at all as far as the bearings themselves are concerned.

When the temperatures previously mentioned are the temperatures of the oil coming from the bearing, no particular harm to the oil will follow provided it is not kept continuously at this point. The capacity of the system should be large enough and suitable cooling means should be provided to reduce the temperature of the oil to around 125 deg. F., before it is returned to the bearings again. In this way the losses due to evaporation and decomposition will be reduced to a minimum.

A very low bearing temperature, on the other hand, does not necessarily indicate ideal conditions. When the temperature is low because of minimum friction within the bearing and proper conduction of generated heat from the bearing and the use of a low-viscosity oil, everything will be satisfactory, but if the low temperature is the result of excessive cooling through the use of large quantities of cold circulating water through the bearing jackets or coolers, the frictional losses within the bearing might be very high because of excessive oil viscosity and still remain unnoticed on account of the great cooling effect of the water. The remedy is to raise the temperature of the bearing by reducing the flow of cooling water, thereby reducing the oil viscosity and lowering the friction, or to use an oil of a lower viscosity at the operating temperature.

Q. What is a safe temperature for oil to be delivered to a bearing when a circulatory system is used?

A. The temperature depends entirely upon the viscosity of the oil and the viscosity requirements of the bearing. Generally speaking, the viscosity requirement of any bearing is the lowest viscosity that will maintain the lubricating film with a sufficient margin of safety. A low temperature is conducive to minimum evaporation losses and decomposition. In most circulatory systems a temperature of 125 deg. F. is about as low as is desirable for proper cleaning of the oil, and on this account the oil coming from the bearings should not be below this point.

If bearings run at a high temperature on account of conducted heat, as is frequently the case in steam turbines, a medium- or high-viscosity oil is necessary in order to give proper lubrication. In this case the oil must not be cooled too low, or its viscosity will rise to a point where it cannot be properly freed from moisture and foreign matter.

The best possible arrangement of piping in the refrigerating plant to keep the low-pressure side free from oil or water is to arrange all piping so that it will drain and so that it will contain no pockets. At each low point there should be installed a suitable trap which may be opened to the atmosphere and connected to discharge to the regenerator.

Steam-Pipe Losses at High Temperatures

By R. H. HEILMAN*

The following abstract of a paper presented at the Spring Meeting of the A. S. M. E., Atlanta, Ga. (May 8 to 11, 1922), tells of some recent experiments on losses from bare steam piping.

THE manufacturers of pipe coverings are frequently required to guarantee that the application of a specified heat-insulating covering will save a certain percentage of the heat that would be lost if the pipe were bare. The percentage of the bare-pipe loss that is saved by the covering is ordinarily called its "efficiency." For example, an efficiency of 80 per cent means that the covered pipe saves 80 per cent, or wastes 20 per cent, of the heat that would be lost under the same conditions of steam temperature and room temperature if the pipe were left bare.

Owing to the fact that the early experiments on bare-pipe losses were conducted at low temperatures, while subsequent investigators generally confined themselves to one pipe size only, the Mellon Institute deemed it advisable to carry on the research to higher temperatures and to pipes of various sizes. By testing pipes of several sizes under the same condition, it was thought that more reliable data could be secured than by comparing the results of other investigators on pipes of various sizes under different conditions. Accordingly, tests were made on 1-in., 3-in., and 10-in. pipe.

The method of testing was practically the same as that described by G. D. Bagley in his paper, "Conservation of Heat Losses from Pipes and Boilers," presented before the A. S. M. E., in 1918, excepting that the pipe-covering tester was improved.

All three pipes were tested up to about 500 deg. temperature difference. Beyond that, up to 700 deg., only the 1-in. pipe was tested as heat given off by the larger pipes would have unduly affected the room temperature. The heat-loss curves for the 3-in. and 10-in. pipes were extended for higher temperatures, and new curves were drawn for other pipe sizes, by paralleling that for 1-in. pipe.

The accompanying table shows the monthly loss in dollars and cents and also in pounds of coal per 100 lin.ft. of horizontal bare iron pipe for temperatures up to 664 deg. F. The loss varies from $1.32 for 100 lin.ft. of ½-in. pipe at 180 deg. F. to $297.50 for 100 lin.ft. of 18-in. pipe at 664 deg. F.

In conclusion attention should be called to a common misconception in regard to the value of air spaces. Although all good pipe coverings owe their heat-insulating value to air spaces, it should be noted that it is *dead* air that causes the insulation, and that this can be obtained only when the pockets are so small that the convection (circulation) effect is negligible.

Attempts have frequently been made to increase the efficiency of insulation on pipes by leaving a large air gap, amounting to ½ in. or more, between the covering and the pipe. A large gap of this sort is not only of no value, but is actually harmful. The small insulating effect of the gap itself is more than neutralized by the fact that the circumference of the pipe covering is increased, so that more area is offered for heat loss.

*Mellon Institute of Industrial Research, University of Pittsburgh.

Gage Press.	Hot Water			10 Lbs.			80 Lbs.			120 Lbs.			160 Lbs.			200 Lbs.			200 Lbs. and 100° F. Superheat.			275 Lbs. and 250° F. Superheat.		
Temp.	180° F			239.4° F.			324.0° F.			350.0° F.			370.7° F.			387.9° F.			487.9° F.			664.3° F.		
Pipe Size	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.	Dollars Loss	Pounds Coal	B.t.u. per lineal ft. per °F. diff. per hr.
½"	1.32	526	.605	2.24	897	.670	3.92	1566	.779	4.51	1805	.815	5.25	2010	.846	5.53	2210	.875	8.60	3440	1.040	16.15	6460	1.375
1"	1.91	763	.878	3.26	1305	.973	5.72	2290	1.138	6.25	2601	1.178	7.27	2910	1.242	8.07	3230	1.280	12.56	5026	1.520	30.55	12220	2.600
1½"	2.65	1060	1.220	4.54	1818	1.357	7.98	3190	1.586	9.28	3710	1.676	10.42	4165	1.751	11.36	4550	1.804	17.94	7175	2.170	34.30	13720	2.920
2"	3.24	1297	1.491	5.36	2142	1.600	9.78	3910	1.943	11.37	4549	2.052	12.75	5100	2.145	14.00	5600	2.220	22.10	8825	2.670	42.20	16890	3.590
2½"	3.86	1545	1.778	6.65	2660	1.984	11.66	4660	2.320	13.66	5460	2.464	15.25	6100	2.564	16.70	6690	2.650	26.64	10650	3.220	50.50	20200	4.300
3"	4.56	1824	2.100	8.24	3292	2.460	13.88	5550	2.760	16.14	6450	2.910	18.04	7210	3.030	19.84	7945	3.150	31.60	12640	3.820	58.25	24300	5.170
3½"	5.18	2070	2.380	8.89	3554	2.655	15.82	6325	3.145	18.31	7322	3.305	20.50	8200	3.450	22.60	9040	3.580	35.90	14360	4.345	69.00	27600	5.860
4"	5.78	2305	2.650	9.87	3950	2.950	17.70	7075	3.520	20.50	8200	3.700	22.85	9145	3.842	25.15	10060	3.981	40.10	16040	4.850	72.40	30920	6.580
4½"	6.35	2540	2.920	10.94	4370	3.260	19.48	7790	3.878	22.60	9025	4.075	25.30	10120	4.250	27.75	11100	4.400	44.05	17620	5.326	85.60	34240	7.286
5"	6.95	2780	3.200	11.97	4790	3.575	21.25	8500	4.232	24.62	9850	4.450	27.60	11050	4.650	30.40	12140	4.805	49.35	19740	5.960	94.50	37800	8.050
6"	8.20	3280	3.775	14.21	5680	4.240	25.30	10110	5.024	29.30	11720	5.295	32.80	13120	5.522	36.00	14420	5.715	57.50	23000	6.955	112.50	45000	9.580
7"	9.40	3760	4.325	16.18	6470	4.826	29.10	11640	5.782	33.70	13480	6.090	37.60	15040	6.324	41.60	16650	6.560	66.25	26500	8.010	129.00	51550	10.97
8"	11.00	4398	5.050	18.25	7300	5.450	32.60	13030	6.455	37.65	15050	6.840	42.40	16940	7.125	46.05	18420	7.300	74.75	29900	9.050	146.20	58500	12.44
9"	11.62	4650	5.350	20.35	8130	6.070	36.25	14500	7.210	42.10	16840	7.600	47.22	18900	7.950	51.98	20790	8.230	83.50	33400	10.10	162.60	65050	13.84
10"	12.68	5065	5.925	22.05	8820	6.584	40.20	16100	8.010	46.70	18690	8.440	52.30	20910	8.805	57.75	23100	9.150	97.50	39000	11.18	180.00	72000	15.30
12"	15.00	6000	6.995	26.44	10580	7.890	47.40	18950	9.425	55.40	22120	10.00	61.76	24700	10.40	70.00	28010	11.14	109.30	43700	13.22	213.50	85500	18.18
14"	16.60	6635	7.625	28.90	11560	8.620	52.00	20800	10.34	60.50	24200	10.92	67.50	27000	11.36	74.10	29650	11.76	119.40	47740	14.43	233.00	93300	19.85
16"	18.82	7525	8.650	32.80	13120	9.790	58.76	23500	11.70	68.40	27320	12.34	76.10	30410	12.80	84.25	33700	13.35	135.00	54000	16.34	265.00	106000	22.55
18"	21.00	8400	9.650	36.10	14460	10.80	65.40	26150	13.00	76.50	30570	13.80	85.50	34200	14.38	93.75	37500	14.87	151.20	60500	18.30	297.50	119000	25.30

LOSSES FROM HORIZONTAL BARE-IRON STEAM PIPES

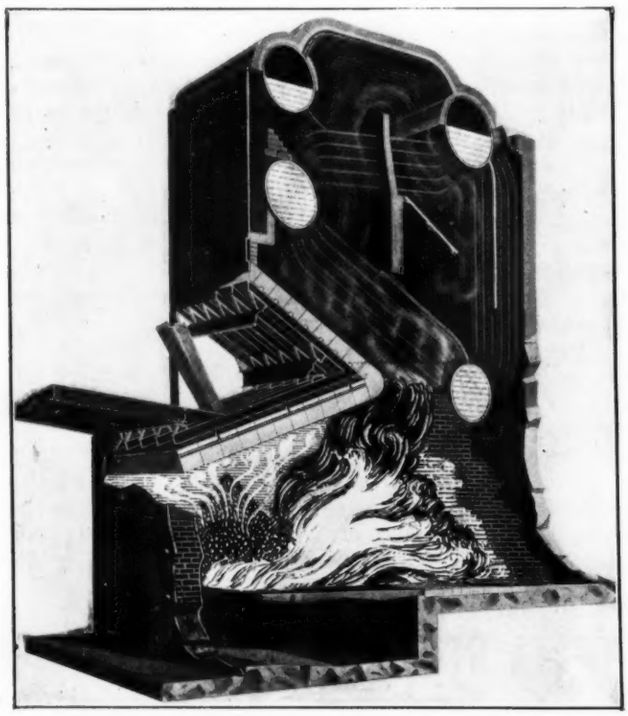
From 100 Lineal Feet of Pipe per Month of 30 Days with Steam in Pipes 24 Hr. per Day. Coal at $4 per Ton of 2,000 Lb.

In this table coal has been figured at $4 per ton of 2,000 lb., 13,000 B.t.u. per lb. of coal; labor, boiler-room expense, etc., taken at $1 per ton, making total value of coal fired at $5 per ton. Boiler efficiency taken at 70 per cent and air temperature at 70 deg. F.

Burning Bagasse in the Gilchrist Furnace

Owing to a moisture content running from 45 to 55 per cent, bagasse (the shredded remains of cane after the sugar has been extracted) is a difficult fuel to burn. With a heat value ranging from 3,700 to 4,500 B.t.u. per lb. and exceeding 8,000 B.t.u. when dry, this waste product is used generally as fuel in the sugar mills with varying degrees of success, depending upon the furnace employed and the degree to which the water vapor retards combustion.

Economies have been so far below theoretical possibilities that W. A. Gilchrist, Peoples Gas Building, Chicago, has perfected a furnace that he had developed previously for the burning of wood offal, the two fuels being much alike, particularly in their moisture content. It was his idea not only to burn but to dry the



GILCHRIST FURNACE FOR BURNING BAGASSE
This waste fuel has a moisture content of about 50 per cent, and so the furnace is designed to dry it before burning it.

fuel in one large compact combustion chamber, obtaining the necessary volume by setting the boiler high and making the furnace as wide as possible. With a long flat arch extending past the boiler front and returning to it in the form of a V to hold the gases in closer contact with the heating surface, together with a vertical bridge wall of large area, the furnace has a great area of refractories to reflect the heat necessary for drying the fuel and for maintaining the temperature required to burn completely the volatile matter. With the three operations—drying, distilling and burning—conducted in one compact furnace that is almost surrounded by refractories, higher combustion temperatures are obtained, more fuel can be burned at higher efficiency, and losses due to radiation, infiltration and incomplete combustion are minimized.

An application of the furnace is shown in the illustration. The fuel, which is fed through the top of the furnace, builds up in the form of a cone, the slope and size of which depend on the height of the furnace. In this cone three different operations go on simultaneously. The upper part of the cone, consisting of the fresh fuel that has been in the furnace but a short time, is relatively cold and cannot rise above 212 deg. until the free moisture that it contains has been driven off. At this low temperature no combustion can take place. In the second zone, which is farther down and around the lower edge of the cone, the fuel has already gone through the drying stage, so that the heat of the furnace is driving off the volatile matter. The lower part of the cone is a bed of burning charcoal.

As there would be a tendency for any cold air that might enter the furnace above the grate, particularly through the feed opening at the top, to be carried along on top of the gases, a practically balanced draft is maintained by a forced-draft fan and damper regulation, so that no air will enter except through the grate. Under these operating conditions the gases have a rolling or mixing action that tends to break up the stratifications and make a uniform mixture. This is considered of especial importance with a long flaming fuel, the heavier volatiles of which break down slowly and the stratification of which is persistent.

A further advantage results from the low gas velocity, in that the small particles of fuel that may be carried away from the grate by the air jets are given an opportunity to settle out of the gas currents and to burn completely within the furnace, instead of being carried out with the products of combustion, which would be the result in the case of a stronger draft through the boiler.

PRELIMINARY TEST RESULTS, BURNING BAGASSE IN A GILCHRIST FURNACE

Boiler, water-tube, surface, sq.ft.	10,250
Duration of test, hours	10
Steam pressure, lb. gage	128.7
Temperature feed water, deg. F.	205
Temperature flue gases, deg. F.	378.5
Moisture in bagasse, per cent	49.83
Per cent of nominal rating developed	108.7
Equivalent evaporation per lb. of bagasse as fired, lb.	2.66
Equivalent evaporation per lb. of dry bagasse, lb.	5.25
Per cent CO_2	13.62
Per cent Efficiency: $\frac{\text{Heat in steam produced}}{\text{Heat in fuel burned}}$	62.11
Per cent Efficiency, corrected for moisture in fuel	78.3

An initial installation has been made in Cuba at the plant of the Eastern Cuban Sugar Corporation, and preliminary data from tests now being conducted by E. W. Kerr, an authority on bagasse burning and at present engineer of the plant and equipment division of the company, indicate satisfactory results from the furnace. Some of the important results of the test are presented in the accompanying table. The corrected efficiency of 78.3 per cent represents the theoretical efficiency with dry fuel, thus giving a basis of comparison with coal-fired furnaces.

The fuel was hand-fed, and some difficulty was experienced in maintaining a uniform supply to the furnace. With suitable mechanical equipment for fuel handling that may draw upon storage in a moment's notice, better results are expected.

Representative Sinnott, of Oregon, has had the House recommit to the Indian Committee his bill authorizing the Interior Department to issue trust and final patents on lands withdrawn or classified as power or reservoir sites, with a reservation of the right of the United States or its permittees to enter upon and use any part of such land for reservoir or power site purposes. Mr. Sinnott stated that the bill had been reported by mistake.

EDITORIALS

Heat Balance Still a Moot Question

DURING the last few years much attention has been given to the subject of heat balance, particularly in large stations operating at a high load factor. It would therefore be natural for one wishing to form definite opinions on the subject to study the heat-balance systems of such plants. While such a study would be illuminating in many ways, it would not answer the question, "What is the most approved method of heat balance?" because there are almost as many methods as there are plants. Everyone knows, of course, that different conditions require different solutions, but it seems surprising at first that highly skilled designing engineers differ so widely in their solutions of almost identical problems. The explanation is that the various methods of maintaining heat balance differ so little in their effect on station economy that the final selection is usually determined by balancing first cost against reliability and other practical operating considerations. Such balancing being largely a matter of experience and judgment, it would hardly be expected that any two engineers would reach exactly the same conclusion.

To get an idea of the various methods of driving the auxiliaries and maintaining a favorable heat balance, consider briefly the systems used in the following large plants, recently erected: Delaware Station, Philadelphia Electric Company; Calumet Station, Commonwealth Edison Company (Chicago); South Meadow Station, Hartford Electric Light Company; Seward Station, Penn Public Service Company; Connors Creek Station, Detroit Edison Company; Lakeside Station, Milwaukee Electric Railway and Light Company; Springdale Station, West Penn Power Company; Colfax Station, Duquesne Light Company; and the Hell Gate Station, United Electric Light and Power Company.

The first four of these plants are similar in the respect that they have no house turbines. Yet they differ from one another in a number of ways. Calumet drives most of the auxiliaries electrically with current taken from the main bus through transformers and gets most of the heat for the feed water by bleeding the main turbines. Delaware, South Meadow and Seward make greater use of turbine-driven auxiliaries. Flexibility in regard to feed temperature was an important consideration at Delaware, where it was planned to reduce the original feed temperature of about 210 degrees to perhaps as low as 140 degrees after the installation of air-removal apparatus. At South Meadow the feed water is heated to 180 degrees or more, any excess of exhaust steam being turned back into the intermediate stages of the main turbines. Seward is in a class by itself, since it uses a hot process of feed-water treating as part of the heat-balance system, this process being operated by the exhaust of the auxiliaries.

Each of the other five plants—Connors Creek, Lakeside, Springdale, Colfax and Hell Gate—uses house turbines and drives the majority of its auxiliaries by motors. In the case of the Hell Gate Station all the auxiliaries, with the exception of a few stand-by units, are motor-driven. In all these five plants the exhausts of the house turbines and the steam-driven auxiliaries (if any) are used directly or indirectly to heat the feed water. At Connors Creek some of the heat for the feed water comes from a high-pressure evaporator, while at Colfax a low-pressure evaporator, operated by the auxiliary exhaust, serves a similar purpose. Springdale also has a low-pressure evaporator, but it is operated by the exhaust steam of the house turbine.

Almost as great a variety of arrangements is found in the relation of the house-turbine bus to the main bus, and of them both to the motor-driven auxiliaries. Lakeside connects the two buses through a transformer. At Colfax the equivalent of a direct connection, without its bad features, is provided through a motor-generator set. Springdale makes provision for shifting individual auxiliaries from one bus to the other and also for connecting the two buses through a transformer bank. At Connors Creek and Hell Gate the buses are kept entirely separate with provision for shifting individual auxiliaries from one to the other.

Warming Up a Large Steam Turbine

HOW much time should be allowed for warming up a large steam turbine before putting it in service, is a question of primary importance in power-plant operation. The tremendous capacity of some of the modern types of machines; the wide range of temperatures between the high- and low-pressure ends of the casing; the expansion, contraction and distortion that must take place in the casing and spindle during the starting and stopping periods; and the serious consequences that can result from improper handling of this equipment—all these have contributed much to the worries of the operating engineer. These worries might have been materially reduced if there had been more inclination on the part of those most familiar with the subject to discuss these problems in public. Open and frank expressions of opinion from the designers and operators no doubt would have prevented much of the false doctrine that has been preached and misconceptions that have been conceived regarding the large turbines.

These machines have come into general use in a very short period of development, and there is much that is not known about them at this time. It is not at all improbable that what is considered good practice today may be discarded a few years hence. But it is known that the turbine should be warmed up while revolving and not while standing still, even though the latter was recommended in some cases a few years ago. Practices that were found to be correct with the large reciprocating engine have proved disastrous with the turbine. Although it is agreed by the best authorities that the turbine should be revolving during the warming-up

process, it is not agreed as to just how long this period should be. The manufacturers are apparently inclined to recommend a somewhat longer duration than some of the well-qualified operating authorities.

In the article, "Putting Large Turbines in Service," in this issue, it is recommended that the period of warming up should continue until the turbine has become thoroughly and uniformly heated, which should be, roughly, one minute for each one-thousand kilowatts capacity with a minimum of ten minutes. This would require thirty-five minutes for a thirty-five thousand kilowatt machine. Some operating engineers are opposed to too long a warming-up period for the reason that the low-pressure end of the machine reaches too high a temperature. These engineers consider that a fifteen-minute warming-up period will give more closely the operating temperatures throughout the machine than will thirty-minute or longer periods. Undoubtedly, there is something in favor of this contention.

The big turbine is here to stay and has proved its economic value, and although there are some rough spots in its record, they are being gradually worked out. This working-out process could be helped materially by discussion of the problems involved in the machine's operation. Therefore, *Power* would welcome for publication an expression of opinion by both the operators and manufacturers as to the best method of starting steam turbines.

Starting Synchronous Motors

TO BECOME a general-utility motor such as the induction types of alternating-current motors have become, is probably outside the sphere of the synchronous type. However, there are many applications where the synchronous motor can compete with the other types of alternating-current machines; in fact, it is even superior to them in some respects. As the characteristics of the synchronous type are more carefully investigated, machines of improved design are being developed and the field of applications of this motor is broadened.

The synchronous machine has a distinct advantage over other types of alternating-current motors in that its power factor can be controlled to almost any desired value, but in starting characteristics it is at a disadvantage. Since the motor's power factor can be controlled, this makes it a very desirable load on most power systems, therefore anything that can be done to make the starting conditions more favorable to the motor will tend to increase its use. One of these applications where the starting conditions may be materially changed in the design of the machine is the ammonia compressor. In fact, if the bypasses on the cylinders are made too small, it may be impossible for the motor to start the compressor in the usual manner.

In the article, "Starting Synchronous Motors Driving Ammonia Compressors," in this issue, A. R. Stevenson gives interesting examples of how the size of the bypass affects the starting of this class of equipment. In one case where the bypass was too small on the compressor, the motor had to develop a pull-in torque of approximately fifty per cent, at ninety-seven per cent speed, whereas on a similar compressor with a large enough bypass, the motor had to develop only about ten per cent pull-in torque and was able to reach synchronous speed in about one-quarter of the time that the former required.

The foregoing clearly indicates what may be accomplished by careful consideration of details in compressor design. Of course this does not mean that the compressor manufacturers should be required to compromise the design of their equipment to favor the motor. But there is an excellent opportunity for cooperation between the compressor and the motor manufacturers.

Reliability of the Hydraulic Turbine

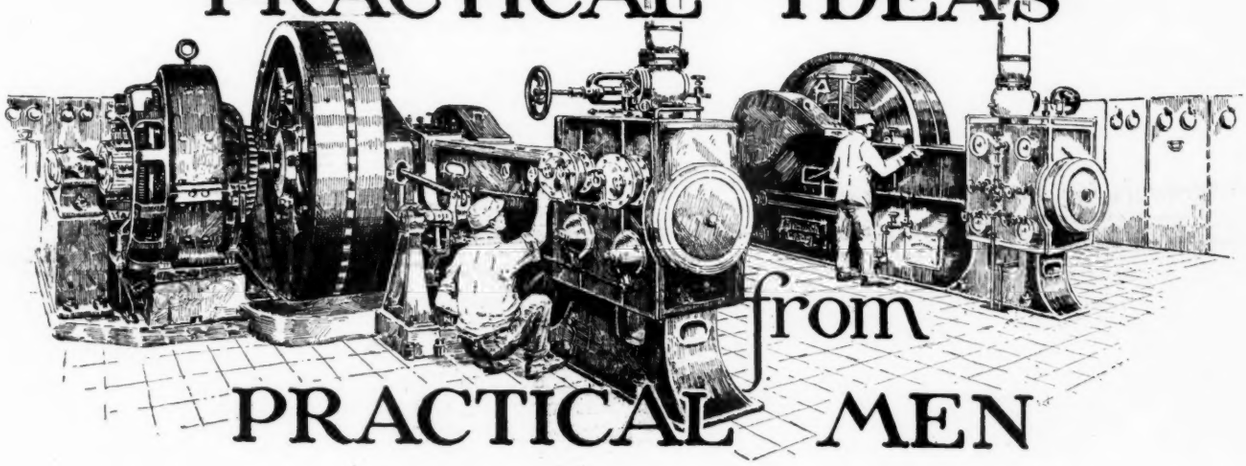
ALTHOUGH the hydraulic turbine has probably had fewer serious accidents than any other type of prime mover, it has not been entirely exempt. However, many of the troubles have been due in part or in whole to improper design. Wheels have been built of incorrect specific speed, which has resulted in excessive corrosion of the buckets caused by the formation of air pockets. Cases are on record where the buckets of ten-thousand-horsepower wheels corroded through in two or three years.

Improper setting of the wheels in open flumes has resulted in eddies that allowed air to be drawn through the wheel, setting up serious vibrations which caused high maintenance charges. Penstocks have burst or collapsed, but in general the turbine has been immune to a high degree from serious or unexpected failures. Large turbines have operated continuously twenty-four hours a day for thirty months without a shutdown. This record has probably never been equaled by any other type of prime mover and bears witness to the durability of hydraulic turbines when properly designed and installed.

The announcement of the failure of the twenty-thousand-horsepower units at Niagara Falls, described on page 747, in the May 9 issue, undoubtedly was somewhat of a surprise to many hydraulic engineers. The exact cause of the failure has not, at this writing, been announced, but if the first reports are correct the trouble started in the generator and what followed to cause the turbines to fail, was a combination of circumstances over which no one had control. These machines were of the well-known horizontal-shaft type, such as are found in many of the large plants throughout the country. They are installed in the open on the power-house floor and are therefore exposed to any flying parts that may have resulted from the first failure of the generator. It required only this to cause damage of vast proportions, whereas if the wheel had been of the vertical type and set in the concrete superstructure, the damage would probably have been confined to one generator.

In a recent wreck of a ten-thousand-horsepower vertical-shaft turbine in which all the guide vanes were broken or bent and every bucket taken out of the runner, the casing remained intact. The damage in this instance might not have been confined to the inside of the turbine casing if it had not been for the reinforcement afforded by the concrete foundation. The results of the investigation being made of the Niagara Falls failure will be awaited with much interest, since if it can be shown that the failure of the turbine casings was due to their being exposed, it will be another strong argument in favor of the vertical-type machine.

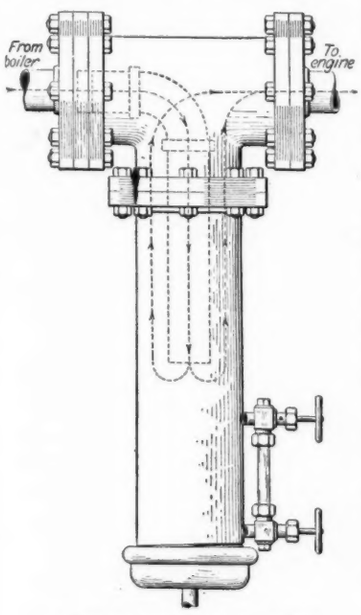
PRACTICAL IDEAS from PRACTICAL MEN



An Improvised Steam Separator

The sketch herewith shows how an engineer improvised a steam separator with some ordinary pipe fittings, and thus eliminated the trouble due to water entering the cylinder of a small vertical engine driving a cupola blower.

A 2-in. pipe supplied steam to the engine. The body of the separator is made of a 6-in. flanged tee, with a piece of 6-in. pipe about 24 in. long, capped at one end and screwed into a 6-in. flange, which is bolted to the branch of the tee.



SEPARATOR MADE WITH PIPE FITTINGS

The internal connection of the steam pipe was made by first truing up the outer rough face of a 2 x 6-in. flange in the lathe, so as to provide a smooth joint surface on both faces. A 2-in. nipple, with an ell attached, was then screwed into this flange, and the flange was bolted to one end of the 6-in. tee. A piece of 2-in. pipe, about 12 in. long, screwed into the open end of the ell, completed the inner pipe. When the separator was finished, it remained simply to couple it into the pipe line, with 2 x 6-in. flanges.

A hole was drilled and tapped for a ¾-in. drain pipe in the bottom cap for connection to a steam trap. Holes were also provided for a gage glass connection. Finally, a thick covering of asbestos was applied to the exposed surfaces. This improvised separator entirely eliminated the trouble of water entering the cylinder, and no doubt there are many small plants where separators of this type might be constructed from spare fittings around the plant.

A. J. DIXON.

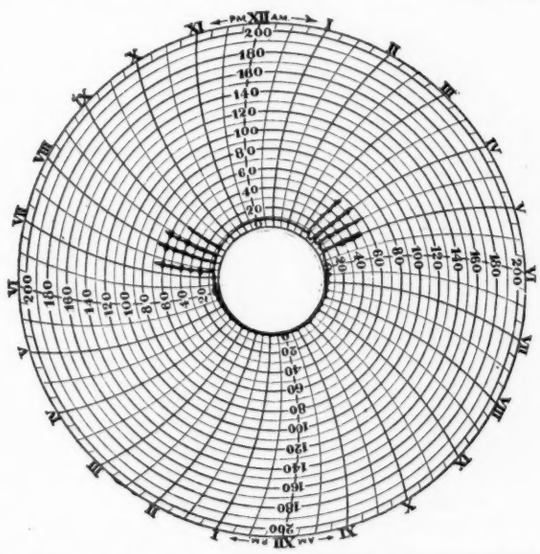
St. Louis, Mo.

Boiler Blow-Down Recorder

I have charge of a boiler plant consisting of five horizontal return-tubular boilers and have had considerable trouble with the scale and mud baking on the rear head and the end of the tubes and causing them to leak badly.

The boilers were supposed to be blown down twice during the night shift. Having instructed the night firemen to blow them down regularly, I could not understand why so much mud and scale had collected as the boilers were washed out and inspected internally and externally every month.

To satisfy myself that my orders were being carried out, I connected a recording pressure gage on the blowoff line between the boilers and the blowoff tank. After the gage had been connected a few days, the charts showed that in three nights the fireman had failed five times to blow the boilers down. Since that time they have been blown down regularly.



THIS CHART SHOWS THAT FOUR BOILERS WERE BLOWN DOWN TWICE DURING THE NIGHT SHIFT

The next time the boilers were washed and inspected, I found the internal condition much better than it had previously been.

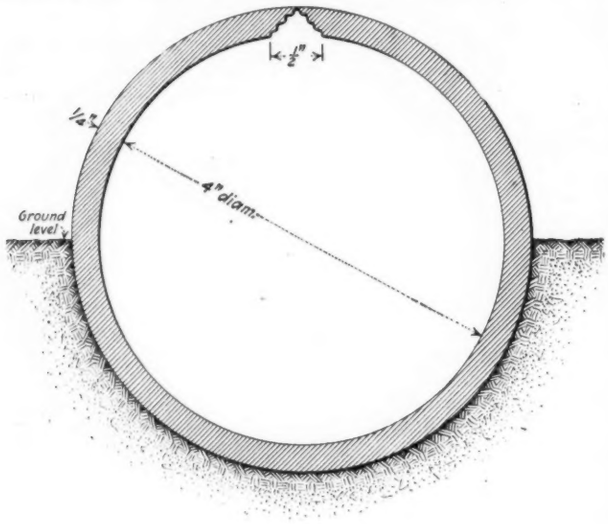
WILLIAM MADER.

York, Pa.

Corrosion Due to Galvanic Effect

On two occasions during my career, once in South Africa and once in India, I have encountered the following trouble:

A pipe line lying across country, half-buried in the ground, has shown signs of corrosion by jets of water



CORROSION OF WROUGHT-IRON PIPE CAUSED BY GALVANIC ACTION

appearing at intervals along the top of the line. Upon investigation the pipe was found to be sound, except in spots along the top. In each pipe corrosion was taking place at more or less regular spacings of about eighteen inches. Some had broken through, others were almost through.

My theory as to the cause was that thermocouples existed due to the variation in temperature between the hot and cold portions of the pipe. It follows, therefore, that one portion of the pipe becomes an anode, while another becomes a cathode. The water, containing slight impurities, acts as an electrolyte, and galvanic action takes place. Since the upper portion of the pipe gets hot at certain hours of the day, due to the heat of the sun, and as it is in this portion that corrosion takes place, the hot portion of the pipe is therefore the anode and the cooler the cathode. Completely burying the pipes in the ground remedied the trouble.

The two curious features of the case were that the spacings between the spots were so even and that these spots were in a straight line on the top of the pipe—so much so that you could look along the line and practically see only the largest jet of water.

Namtu, Burma. M. H. T. CRISP.

Loose Connection on Commutator Caused Voltage to Fluctuate

When operating a small alternator on the night load of a plant, it was noticed that the voltage dropped from 2,300 to 2,100 on a load that was chiefly light. The exciter's commutator had been turned down and had been giving good service for two weeks. In looking for the cause of the trouble, the brushes on the exciter and alternator were examined and watched while the machine was in operation, but no indications of anything being wrong was discovered.

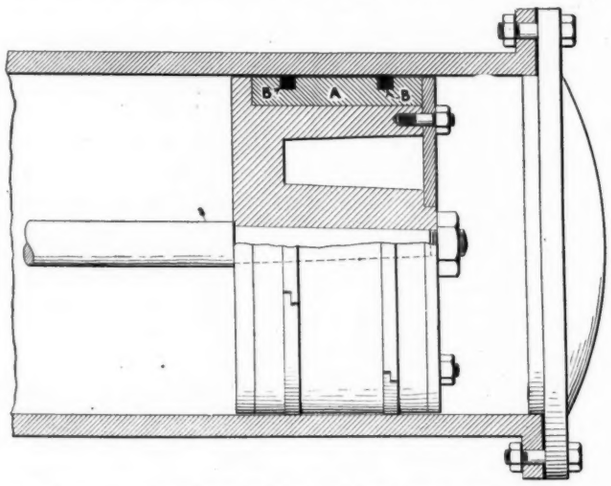
When applying fine sandpaper to the commutator, it was noticed that the voltage fluctuated more during this period than at any previous time. Upon examining the commutator after shutting the machine down, it was found that one of the coil leads was making poor connections with its commutator segment. Soldering the coil lead in place removed all trouble, and the voltage remained normal when the machine was again put into service. ARTHUR K. GENTZLER.

Burke, S. D.

Metal Packing Rings for Water Pump Decrease Shutdowns

About three years ago one of the water-supply pumps at the Houston Electric Co.'s LaBranch Street power plant was taken down and overhauled. The water-cylinder liner, which was found to be badly scored, was taken out, rebored and reinstalled. Instead of repacking the piston, however, the packing groove was filled by a cast-iron collar fitted with two step-cut cast-iron rings, a section of which is shown in the illustration. The outside diameter of the collar *A* is the same as that of the cylinder bore, less a running clearance, and the thickness is equal to the depth of the packing groove and the length sufficient to insure rigid clamping by the holding plate. This arrangement was found to work well when both liner and rings were of cast iron, but was not satisfactory when used in a brass liner. The pump has not been used in handling river water, but has given satisfactory service in supplying the plant with artesian-well water.

This pump has been in service for the last three years, supplying an average of 850,000 pounds of water



PACKING ON WATER PISTON REPLACED BY CAST-IRON COLLAR AND RINGS

daily at 50-lb. pressure. It also serves as a fire pump, and its emergency output is several times that of its daily output. When using hydraulic packing, the pump had to be shut down and repacked at least every three months; and now, after three years' service, the cast-iron rings seem to be doing the work with no more expense than the initial cost of installation.

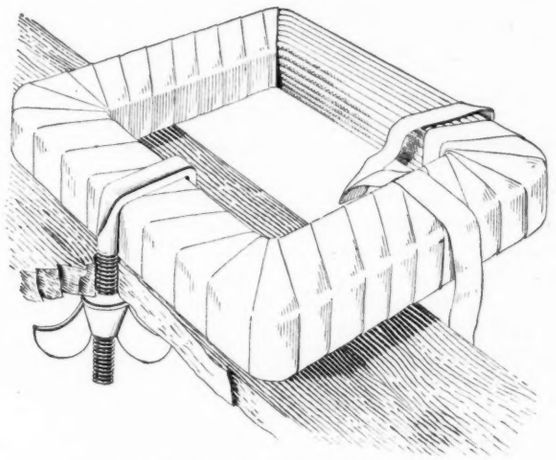
In the case of a pump fitted with a brass liner, if the collar *A* is also made of brass and fitted with brass or bronze piston rings, it should give equally as good results. MACK ELLIS.

Houston, Tex.

A Handy Method of Taping Field Coils

In taping up small field coils that have been wound or that are being reinsulated, the simple device shown in the diagram is convenient for holding the coil.

A piece of $\frac{5}{16}$-in. round iron is flattened on one end and bent into a hook that approximately fits the contour of the coil that is to be taped. On the other end the rod is left round and is threaded to take a wingnut, as indicated in the diagram. A hole is drilled through the workbench at such a distance from the edge that when one end of the field coil is clamped under the hook a little more than half of the coil hangs over the edge of the bench. After taping half of the coil, the clamp is loosened, the coil turned end for end and the other half taped.



COIL CLAMPED TO BENCH FOR TAPING

C. E. PARHAM.

Brooklyn, N. Y.

Improved Method of Cylinder Lubrication

It is customary to supply each steam engine with its own cylinder lubricator. These lubricators are wasteful, generally being set to pour more oil than necessary. Also wastage takes place in filling them, because the heavy oil enters the small filling opening of the lubricator with difficulty. In a factory where a number of engines and steam pumps are used regularly, the wastage of oil will be considerable.

To prevent this loss I suggest that only one lubricator of a larger size, be placed on the steam main and the number of drops passing out regulated by the number of square inches of surface requiring lubrication. A considerable saving of cylinder oil will be effected for the following reasons: (1) Leakage of oil through glands, etc., on account of not overfeeding, reduced; (2) wastage while filling lubricator is less; (3) loss of oil from overfeeding, especially small units, is minimized.

Bogota, Colombia. O. JANZEN.

Why Cannot the Generators Be Connected in Parallel?

In the figure are shown the general connections for two 7,500-kva. 5,000-volt three-phase alternators. Power distribution is through two 7,500-kva. 5,000- to 33,000-volt three-phase delta-to-star connected transformers; two 1,000-kva. 5,000- to 525-volt three-phase transformers connected star to star; and at 5,000-volt directly from the generators. The two latter are for local distribution and the former for long-distance supply. The generators are connected in star with their neutral points grounded through a 5-ohm resistance. In this circuit is a current transformer which operates the neutral relay in case of a heavy current flow to ground. The generators are also protected by balanced differential relay connections. On the high-tension side of the step-up transformers the neutrals connect to a common bus which is grounded through a 26-ohm water resistance.

In normal operation both machines feed into the 33,000-volt bus, one machine connects to the 5,000-volt bus and each machine connects through a transformer to a section of the 525-volt bus. This puts the generators in parallel on the 33,000-volt bus only. All neutral disconnect switches are closed and this plant operates in parallel with two others.

When it is required to parallel the generators on the 5,000-volt bus, it is necessary to open the ground connection on one of the generators. If one of the ground connections is not open when paralleling the machines, a heavy circulating current is set up between the two machines, which generally results in tripping one or both of them off the line. In this case the generators are already in parallel through the transformers on the 33,000-volt bus.

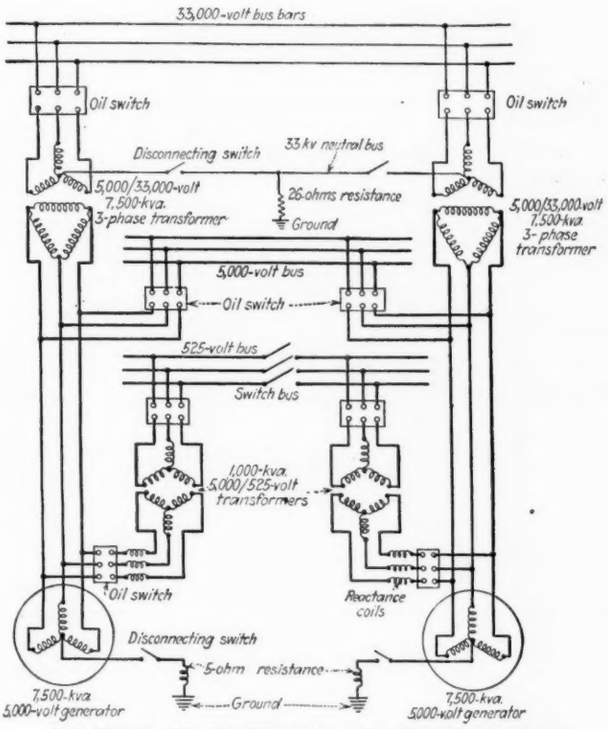
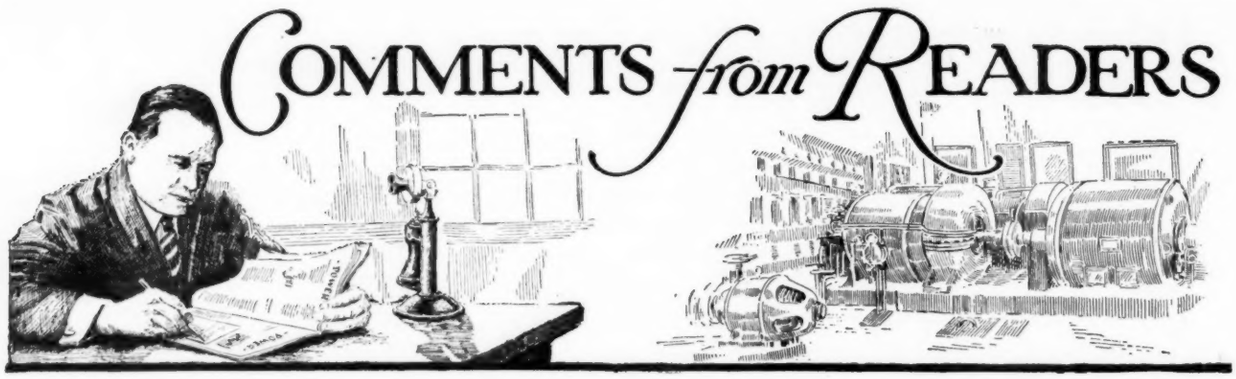


DIAGRAM OF GENERATOR AND TRANSFORMER CONNECTIONS

I would like to have some of *Power's* readers give an explanation for this abnormal current. Why does it not occur when the machines are paralleled on the 525-volt bus, both the neutral switches being left closed? Is it possible to overcome this trouble without opening either of the generator neutral switches?

ALBERT BANKES.

Ventsberg Road, Orange Free State,
South Africa.



Load on Main-Bearing Caps

In the March 14 issue of *Power*, page 427, under the heading of "Load on Main-Bearing Caps of Horizontal Engines," Mr. Turnwald erred in resolving the force along the connecting rod into tangential and radial components. Since the tangential force is applied at but one point in the crankpin circle and not at all points, the vertical component of this force must be taken into consideration when calculating the load on the main-bearing caps.

Also, we must take into consideration the inertia effect of the moving parts and use the force on the crankpin instead of the load on the piston. This force can easily be obtained from the crank effort diagram. Referring to Fig. 1, the force P is the piston load corrected for the inertia effect of moving parts, L is the angle the conecting rod makes with the center line of the engine, and B is the angle from head-end center. Then the vertical force F equals P tan L.

$$\text{Tan } L = \frac{\text{Sin } B}{\sqrt{R^2 - \text{Sin}^2 B}}$$

where R equals the ratio of connecting rod to crank. Then

$$F = P \frac{\text{Sin } B}{\sqrt{R^2 - \text{Sin}^2 B}}$$

The curve in Fig. 2 is based on this formula. The load on caps is shown in percentage of horizontal load

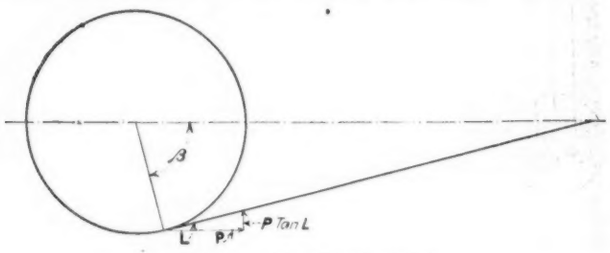


FIG. 1. CRANK DIAGRAM

on the crankpin in order to compare with the curve in the article, but it could as easily be shown in per cent of crank effort, which would be more logical.

Just a word concerning the pressure on the caps when starting and when running. Owing to the low inertia of the moving parts when starting, the piston load will have a greater effect on the caps at that time, but the centrifugal force of any unbalanced parts attached to the crankshaft will be small, while at higher speeds the centrifugal force will increase and the force on the crankpin will decrease. The centrifugal force will amount to considerable in the case of heavy counterweights, as used on oil or gas engines. However, on oil and gas engines the centrifugal force of the counterweights is pulling down when the piston load is lifting up, hence overcoming each other to a certain extent. And when the centrifugal force of the counterweights is pulling up, the compression in the cylinder is pushing down.

Of course, as Mr. Turnwald says, we should also take

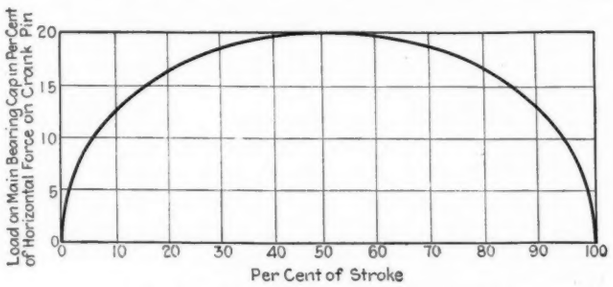


FIG. 2. LOAD ON BEARING CAPS

care of the weights of flywheels, crankshaft, etc.; also any other force such as belt pull, if not horizontal.

Another thing that should be considered besides the weights of rotating parts, is the centrifugal force of any part that is not balanced, which amounts to considerable in the case of heavy counterweights as used on oil or gas engines.

L. L. COLLINS.

Franklin, Pa.

Preheating Air to Boiler Furnaces

There has been considerable discussion recently in *Power* on the subject of preheating the air for boiler furnaces. In the opinion of the writer, this is an effective method of producing a vigorous combustion and in reducing the amount of excess air to the minimum.

Air is more suitable for active combustion when the temperature is raised close to the ignition point of the fuel, and the closer this temperature is to the ignition point the more economical combustion will be produced.

As the volume of a gas or air is proportional to its absolute temperature, if the furnace air is preheated from normal temperature to, say, 500 deg., its volume is practically doubled, and, difficulty is then experienced in getting sufficient weight of air into the furnace. For this reason many attempts at preheating air have not proved a success.

I do not consider it practical to utilize the gases that have passed through an economizer for preheating the air in a natural-draft plant, as the drop in temperature not only impairs the draft, but may reach the dew point and cause corrosion.

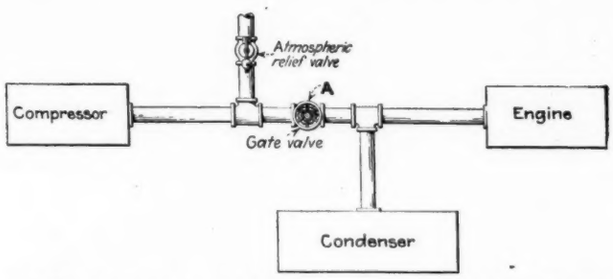
Attempts have been made at preheating air by using the exhaust from high-pressure engines, also the exhaust from auxiliaries, which was not required for feedwater heating. This method gives a low temperature range.

From my experience the most practical system is one that employs the closed ashpit and provides for preheating the air by flowing it over a bank of tubes installed in the gas uptake, and where provision is made for delivering a portion of the air over the fire.

New Bedford, Mass. R. G. SPOONER.

Why Does the Vacuum Drop?

Referring to Mr. Snyder's problem in the April 18 issue, "why does the vacuum drop," he states that with the valve *A* closed and a vacuum of 27 in. in the condenser, when the compressor is started the vacuum drops to 5 in. This is undoubtedly due to the gate valve *A* not closing tightly, and when the relief valve is opened by the exhaust of the compressor, air is drawn into the condenser past the valve *A*.



GENERAL ARRANGEMENT OF UNITS AND CONDENSER

New York City. P. MOLLOY.

[Similar replies have been received from J. F. Hurst, Louisville, Ky., Karl Hein, Kalamazoo, Mich., and Clement Corey, Uxbridge, Mass.—Editor.]

Evaporators for Small Boiler Plants

In a letter in the April 11 issue, George H. Gibson states that the use of evaporators reduces plant efficiency by taking away the opportunity to use bleeder steam from the main turbine for heating the feed water. With a properly correlated evaporator system this is not the case. In the first place, where is there a small steam plant equipped to bleed steam from mid-stage of the main turbines? In many turbines this is not only impractical but, from the nature of the units, impossible. Even in the largest plants it has been found uneconomical to bleed steam at a higher pressure than 5 lb. gage. This would not permit of heating the feed water to more than 215 deg. F. There is ample temperature range above this point to absorb the heat from the last-effect vapor of a multiple-effect evaporator plant, in a high-pressure condenser before the feed water enters the boilers.

In Mr. Gibson's example he has taken a single-effect plant producing 10 per cent makeup. It would be an exceptional plant indeed in which such an installation would be recommended. Usually, 10 per cent makeup is almost double that encountered in a well-ordered condensing station, although it can be cared for economically by evaporators. Again, a two- or three-effect evaporator plant would be installed if the feed water were already heated by auxiliary exhaust or bleeder steam to, say, 210 deg. Evaporator steam drains frequently are pumped directly into the boiler-feed line, and hence the heat is returned to the boiler.

To sum up, Mr. Gibson's hypothetical case of a plant bleeding high-pressure steam at a large number of stages to heat the feed water to boiler temperature does not exist in practice in either large or small plants, and is an impractical, costly installation which probably never will exist. J. W. MCCAUSLAND.

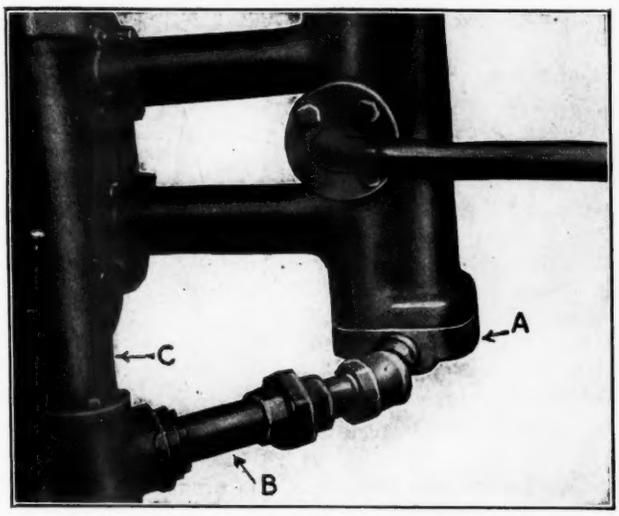
Chicago, Ill.

Eliminating Pilot Valve Pulsation

I read with considerable interest the communication by T. A. Marsh on the subject of giving publicity to useful kinks, in which he urges engineers to write for publication descriptions of special devices or improvements that have been worked out and found practical.

In the operation of a 12,500-kw. turbine we experienced governor trouble for several years. The governor arm and connections to the pilot valve of the hydraulic cylinder would pulsate badly, often sufficiently to affect the operation of the steam-control valves. We made several attempts to eliminate this vibration by attaching an oil dashpot to the governor arm and by changing the oil pressure up and down from the normal pressure carried. The governor was overhauled several times and all lost motion taken out of the arm and links; the pilot valve and bushings were also renewed. After making these changes, the governor would run quiet for several months, but the old trouble would recur.

The cause of the pulsation was finally discovered by operating the pilot valve by hand with the oil pressure on. It was found that the valve was unbalanced and this was caused by the oil discharge being at the top of the valve chamber.

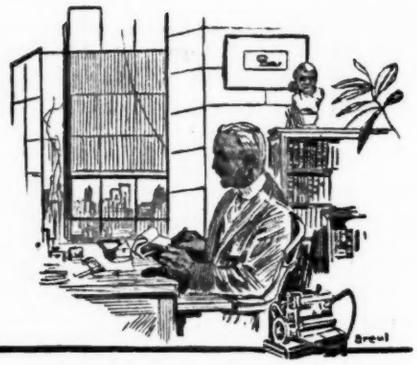


OIL DISCHARGE CONNECTED AT BOTTOM OF PILOT-VALVE CHAMBER

The changes made to overcome this are shown in the cut. The cap *A* on the bottom of the pilot valve chamber was replaced with one having a 1¼-in. pipe connection. This was connected as shown at *B*, to the 2-in. discharge pipe *C*. Giving the valve chamber a discharge port at the bottom eliminated the trouble with the governor. Y. H. DOLLING.

Toledo, Ohio.

QUESTIONS AND ANSWERS



Engine Power Required for Generator

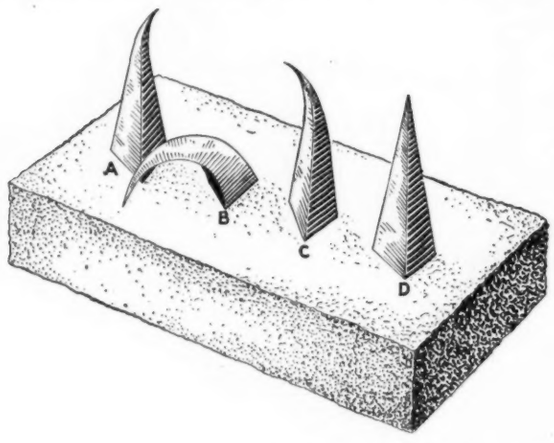
What power must be developed by a direct-connected engine for running an electric generator to develop 85 electrical horsepower? H. E. M.

The indicated horsepower required to be developed by the engine would depend on the efficiency of the generator and the mechanical efficiency of the engine. The efficiency of the generator would be about 90 per cent and the mechanical efficiency of a suitable engine would be about 88 per cent, and therefore an engine suitable for the purpose would be required to develop about $85 \div (0.90 \times 0.88) = 107.3$ indicated horsepower.

Seger Pyrometer Cones

What are Seger cones and how are they used to determine temperatures? R. N. C.

For many purposes where a pyrometer cannot be used, high temperatures may be approximately determined by employing solids whose fusion points are known. But instead of relying on the fusion of crystalized substances which pass abruptly from the solid to



the liquid state, use is made of the progressive softening and distortion of standard mixtures and forms of materials known as fusible cones. The Seger pyrometer cones comprise a series of triangular pyramids 50 mm. (1.97 in.) high and 15 mm. (0.59 in.) wide at the base, made of several different oxides mixed in proportions to give definite melting points.

Four of these cones are shown in the figure.

The temperature at which a pyramid bends over so far that its apex touches the supporting surface determines a point on Seger's scale.

The cones are carefully graded and the temperature corresponding to the number on the cone can be estimated to about 10 deg. centigrade.

When a series of cones is placed in a furnace whose temperature is gradually raised, one cone after another will bend as its temperature of plasticity is reached.

Hence the highest temperature reached when cones shown in the illustration were used was about halfway between the temperatures corresponding to the cones *B* and *C*.

Dealers in chemical supplies furnish standard Seger cones with melting points of 590 deg. C = 1,049 deg. F., advancing by 10 deg. C., to 1,850 deg. C. = 3,362 deg. F.

Operation of Vacuum Pump

Can a perfect vacuum be formed in the suction chamber of a vacuum pump? A. B. N.

Although the piston and valves may be perfectly tight, a perfect vacuum cannot be formed, because air expands indefinitely and some air or vapor remains in the clearance spaces of the pump and connected spaces after completion of the discharge stroke. During the suction stroke any air that was left in the clearance spaces mingles with air drawn into the pump and the whole volume expands by an amount equal to the piston displacement.

Upon the return stroke the suction valves close and the air in the pump cylinder is compressed until the pressure is sufficient to open the discharge valve against the pressure of the atmosphere and at end of the discharge stroke the clearance spaces at the end of the pump cylinder remain filled with air at the pressure that was necessary to discharge the air from the cylinder against the pressure of the atmosphere.

Oil Pumping in High-Speed Gasoline Engine

What causes pumping of lubricating oil in a high-speed splash-oiling gasoline engine? R. N. M.

The fuel leakage past the piston rings of an internal-combustion engine is naturally dependent upon the conditions of the pistons, cylinders and rings, Correctly designed and well-fitted rings, in true cylinders, resist these leakages until a point is reached where the dust and dirt that enter the engine with the air, in conjunction with the diluted and reduced lubricating oil film on the cylinder walls, bring about a cylinder wall and ring face wear, the worst effect of which is the gradual widening of the piston-ring groove caused by the up-and-down slapping of the ring. This creates a direct passage for the leaking of fuel and the escaping or "pumping" of the lubricating oil from the crankcase.

If the height of the oil in the crankcase is high, the entire crankcase becomes filled with a fog of oil and air. This fog will be pulled up along the piston during the suction stroke.

Testing Gas Supplied to Producer Gas Engine

When looking for defects in an engine, the quality of the gas is often overlooked. How is it possible to know the quality of gas being used in a producer-gas engine? E. J. P.

Upon starting, the test cock on the producer should be opened and the gas tested by igniting with a match. The flame should be a reddish blue color. Often, while running, the gas will become so lean as to fail to fire in the engine cylinder. However, as long as it will ignite at the test cock, the gas should fire in the cylinder.

Excessive Wear from Improper Lubrication

Will a thin lubricating oil cause excessive wear in an internal-combustion engine cylinder? H. C. C.

Lubricating oil, primarily is for the purpose of keeping surfaces apart so that they will not strike. If the oil becomes so thin that the film interposed between the two surfaces is insufficient to prevent contact of those surfaces, local heating is immediately established where the striking takes place, and the oil at that spot becomes suddenly thinner at the very moment when thicker oil is needed. As the oil becomes thinner through heat or dilution, the locality where the striking occurs becomes more extensive in area and the wear is increased. In an automobile engine this wear may continue for some time as in the case of the wear of textile spindle, but eventually it causes a marked deterioration in the engine. Many of the ills of the engine can be traced directly to this wear. Among the common automobile engine ailments caused by this condition are oval cylinders caused by wear, worn piston rings, pumping of oil into the explosion chambers, loss of compression, the noisy operation and burning out of the bearings.

Bumped Head of Radius Equal to Diameter of Shell

Why does not a bumped head require staying if it is bumped to a radius equal to the diameter of the cylindrical shell and made of the same kind and thickness of steel? W. L. B.

To obtain the intensity of hoop stress in a thin hollow cylinder due to a given working pressure, take a unit of length Fig. 1 where

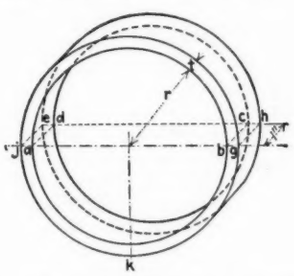


FIG. 1. ILLUSTRATING STRESS IN THIN HOLLOW CYLINDRICAL SHELL

r = Internal radius of the cylinder in inches;

t = Thickness of metal in inches;

p = Intensity of internal pressure, pounds per sq.in.;

f = Intensity of hoop tension or stress per square inch of section of the material.

Considering one half *jkghe* as a solid body, the total force tending to raise the upper half of the cylinder from the lower half would be the pressure p acting on the area $ab \times ad$ or $p \times 2r \times 1$. One half of this total pressure, or pr, is resisted by each of the sections *adej* and *bchg*, each of which has an area of $(t \times 1)$ square inches. Hence f, the intensity of hoop tension or stress per square inch of section, is

$$f = \frac{pr}{t} \qquad (1)$$

To obtain the intensity of hoop stress in a thin hollow sphere due to a given working pressure, let Fig. 2 represent the upper half of a sphere with a thin shell where

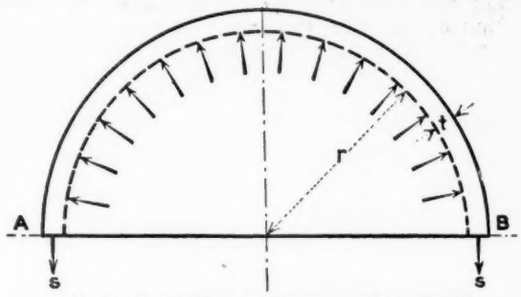


FIG. 2. ILLUSTRATING STRESS IN THIN SPHERICAL SHELL

r = Internal radius of sphere, in inches;

t = Thickness of shell;

p = Intensity of internal pressure, pounds per square inch;

s = Intensity of tangential stress or hoop tension per square inch of section of the material.

Considering this portion of the sphere as a solid body, the total force tending to raise it would be the area of the base AB in square inches multiplied by the pressure per square inch or $\pi r^2 p$. This must be equal to the total stress resisted by the shell at the section AB or $2\pi rts$. Therefore $\pi r^2 p = 2\pi rts$, or

$$s = \frac{pr}{2t} \qquad (2)$$

Hence, for the same radius r and thickness of material t a given pressure p exerts one-half the intensity of hoop tension in the case of a sphere as in the case of a cylindrical shell.

From inspection of (1) and (2) it is seen that the stress in each case is directly in proportion to the radius and when the thickness of material and pressure are the same, the stresses will be equal when the radius of the sphere is twice the radius of the cylindrical shell. As the same would hold true for a segment of the sphere, it follows that when the head in a cylindrical shell is made of the same thickness and strength of material and bumped to a radius equal to the diameter of the shell, the spherical portion will resist any pressure that is safe for the shell.

Trouble from Leaky Tubes

We have three hand-fired return-tubular boilers that give much trouble from leakage around the tube ends when the boilers are fired with soft coal, but there is little leakage when firing hard coal. How can the trouble be prevented? W. L. D.

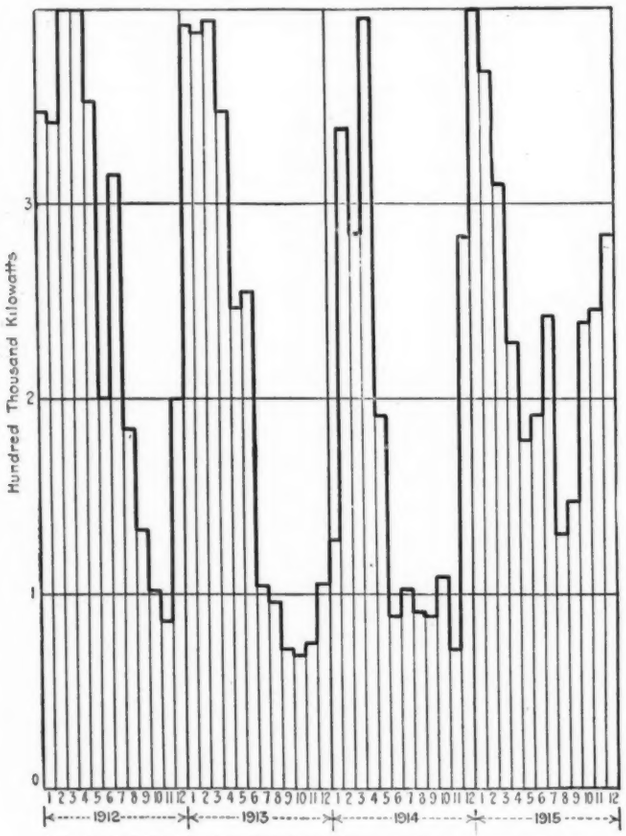
The greater trouble when burning soft coal undoubtedly results from incompletion of combustion before the gases reach the back connection of the combustion chamber, due to insufficient height of the boilers above the grates. Better results would be obtained by having the boilers set higher above the grates and by firing lighter and oftener. If the tube ends are beaded over, they will be better protected from the fire.

Power Development in the Southeast*

By Charles G. Adsit
Executive Engineer, Georgia Railway and Power Company

The southeastern section of the United States, traversed by the great Appalachian Mountain Range, which rises to an altitude of from one to seven thousand feet above sea level, enjoys an average annual precipitation greater than that of any other section of the country. In the foothills of this mountain range are many streams and rivers which have a fall, as a rule, too great for them to be navigable and so lend themselves admirably to economical development.

It is intended to deal herein largely with the water-power and steam-generating stations that are now connected to



POWERGRAPH OF TENNESSEE RIVER AT MUSCLE SHOALS FROM 1912 TO 1915

the transmission system covering the five states of Alabama, Tennessee, Georgia, North and South Carolina.

The table gives the installed capacity of the various power developments that are connected to the system under discussion. It will be noted that the total installed capacity is 1,010,355 hp.

New developments are constantly being made by the various power companies comprising this system, and there is now under construction an additional 310,000 hp. capacity in generating equipment. This does not include 90,000 hp. which will also be installed as an addition to one of the new plants at a later date, nor the much discussed Muscle Shoals development.

The steam-generating stations of the Southeast, generally speaking, supplement the water-power production. Many of the water-power plants are, however, also backed by large storage reservoirs, making their annual output practically continuous regardless of dry months or dry years. On the head waters of the Catawba River, the Southern Power Co. has constructed a large storage reservoir at Bridgewater, N. C., which has a capacity of 13,500,000,000 cu.ft., representing 90,000,000 kw.-hr. under present conditions at the various water-power plants already constructed below. The Georgia Railway and Power Co. has two storage reservoirs on the Tallulah River, one at Burton containing 5,280,000,000 cu.ft. and one at Mathis containing 1,369,000,000 cu.ft. This total storage on the Talullah River represents approximately 70,000,000 kw.-hr. at the present developments and makes available for use in power production at the plants below, about 95 per cent of the annual stream-flow. This storage will later be equivalent to 125,000,000 kw.-hr., when other developments contemplated and under construction are completed.

*Excerpt from a paper presented at the Spring Meeting of the American Society of Mechanical Engineers, Atlanta, Ga., May 8-11, 1922

Undeveloped Resources

While the Southeast has enjoyed extensive hydro-electric development already, it still has many sources of potential water power available for development as rapidly as the demand for electric power increases, and it will be many years before the entire possibilities of the streams in this section are exhausted. There are many industries not supplied at present with hydro-electric power which are depending upon the cheapness of fuel in the section where they are operating, and which in time will turn to electrical energy for their power needs.

Volumes have been written in the Government records and in the press regarding the hydro-electric power possibilities of Muscle Shoals. It is distinctly a run-of-river proposition, as no storage is created by the dam except that required to control the daily flow of the river. The Government at the present time has a requirement in existence for the benefit of navigation below, which will not allow the control of river flow under 10,000 cu.ft. per sec. The lowest stream flow ever recorded was 6,900 sec.-ft., which corresponds to a load of 43,125 kw. under the proposed plans for the development.

The greatest fluctuation in any stream in the Southeast probably occurs in the Tennessee River. The United States Government in planning a development at Muscle Shoals recognized this fact and contemplated an installation of 400,000 kw., only a portion of which can be depended upon for continuous power. According to the hydrographs of the

GENERATING STATIONS OF THE POWER COMPANIES OF THE SOUTHEAST

Hydro-Electric Stations	KW.	Steam Stations	KW.
Alabama Power Co.			
Lock 12	72,000	Warrior	60,000
		Gadsden	10,000
		Birmingham	10,000
Tennessee Power Co.			
Parksville	15,000	Parksville	6,125
Hales Bar	37,100	Nashville	15,500
Great Falls	7,800	Knoxville	6,125
Ocoee No. 2	10,500	Chattanooga	3,000
Georgia Railway and Power Co.			
Tallulah Falls	72,000	Atlanta No. 1	11,000
Morgan Falls	10,500	Atlanta No. 2	10,500
Dunlap	2,200		
Chestatee	1,100		
Gregg Shoals	1,200		
Columbus Power Co.			
Goat Rock	11,000	Columbus, Ga	9,000
North Highlands	6,900		
Central Georgia Power Co.			
Lloyd Shoals	14,400	Macon Nos. 1 and 2 each	1,500
Southern Power Co.			
Bridgewater	20,000	Eno	10,000
Lookout	18,000	Greensboro	6,800
Catawba	4,800	Mount Holly	6,800
Fishing Creek	30,000	Greenville	6,800
Great Falls	24,000		
Rocky Creek	24,000		
Wateree	56,000		
99 Islands	18,000		
Carolina Power and Light Co.			
Buckhorn	2,900	Florence	1,500
Blewetts	33,100	Raleigh	3,720
		Goldsboro	1,200
Total kw.	492,500	Total kw.	181,070
Total hp.	738,750	Total hp.	271,605
Total developed horsepower, hydro-electric and steam			1,010,355

river at this point, the amount of strictly primary power at Muscle Shoals averages about 100,000 hp., and even this figure is based on the assistance of some steam capacity which must be maintained.

The chart shows a powergraph of the river for four consecutive years, 1912-15, which are typical years, based on an installation of 400,000 kw. capacity, as proposed by the United States Government at Dam Site No. 2. It will be noted that in each of these years except one the stream flow at some times falls below 100,000 kw., and that only at widely separated intervals does the stream flow equal or approach the 400,000-kw. mark. It can be seen from these hydrographs that the statement of one million horsepower which has appeared in the press repeatedly, is a gross exaggeration of the output to be expected from the plant of this location.

From the foregoing it can be seen that the Southeast is open for great industrial development, as it either has developed or can develop the necessary hydro-electric power and enjoys the natural advantage of an even climate, together with a very large store of raw materials in both its agricultural and mineral resources.

Turbine Drive for Lancashire Cotton Mills

(From our London Correspondent.)

The typical method of driving the Lancashire cotton mill may be said to be by means of one large horizontal, slow-speed, compound condensing steam engine, with heavy flywheel and rope drive to each floor of the mill. The average steam pressure ranges from 120 to 160 lb., and in some of the more modern installations, 180 lb. The steam consumption of the engine will average about 11½- to 12 lb. per indicated horsepower per hour, working on about 27¾-in. vacuum. The boilers used are always of the "Lancashire" type—that is, cylindrical, double-flued, internally fired—and probably something like 25 per cent of these boilers are mechanically fired, either with sprinkling or coking stokers. In general, the boiler plants are kept in good order. The average temperature of the water going to the economizers is around 100 deg. F., and 250 to 270 deg. to the boilers. Superheaters are also generally used.

It must be confessed that this type of installation has proved, by almost half a century's experience, to be a very efficient one. Moreover, it has been found extremely reliable, and breakdowns and trouble are almost unknown. It is customary for a Lancashire firm to put down a cotton mill and pay little attention to engine and boilers for about twenty years, which can be taken as a reasonable average duration of life.

It must be remembered that the cotton mill is run simply for the production of cotton goods and any stoppages are most serious. It is for this reason, for example, that there is such a prejudice in the Lancashire cotton industry against the water-tube boiler and against what the Lancashire cotton-mill man would term "new-fangled ideas" in the way of steam turbines. There are one or two cotton mills in Lancashire running on steam turbines, just as there are one or two mills with large gas-engine drives, while a small number of mills are electrically driven from central station current, but these are exceptional.

However, a determined fight is now being made by the steam-turbine manufacturers to apply them to the driving of cotton mills. In this connection a fine working model of a steam turbine, specially designed for driving cotton mills mechanically, is being exhibited in Manchester by the Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park (formerly British-Westinghouse), which manufactures the Rateau impulse turbine in Great Britain. In this model the engine room is shown equipped with a high-speed steam turbine, equipped with reduction gearing and rope wheel, driving shafting to the various floors of the mill. That is to say, it is an attempt to replace the steam engine by the steam turbine, but to retain the multiple rope drive which is in such favor in Lancashire. The Metropolitan Vickers company is making this turbine in standard sizes from 800- to 2,000 hp. specially to cover the requirements of textile mills. High efficiencies are guaranteed. For a turbine of 1,500 hp. under average conditions, the makers guarantee that the steam consumption will not exceed 10 lb. per b.hp. per hour, with a steam pressure of 180 lb., 180 deg. superheat, and a vacuum of 28½ in. This is equivalent to a steam consumption of about 9 lb. per i.hp., as compared with the modern cotton-mill engine of 11½ lb. This is of the greatest importance when it is borne in mind that in the cotton industry 80- to 90 per cent of the steam generated is used for power purposes only, the remainder being utilized to heat the mill, for slashing, and various other purposes. The steam turbine is fitted with a condenser of the low-level multi-jet type, but a surface condenser can also be supplied if required. The condenser pumps are driven by ropes from the main turbine, another special adaptation for the cotton industry, but a small steam engine is also provided for driving these condenser pumps until the turbine has got up its speed when the engine is cut out by means of a clutch. If electricity is available, a small motor can be used instead of this engine. In the particular model shown in Manchester a small direct current generator is also supplied with the installation, which can be driven either from the small engine or from the main turbine, two special clutches being provided. This should prove extremely valuable for pilot lighting and for week-end purposes when overhauls and repairs are being carried out.

For a large cotton mill, however, there is no question that the most economical installation is the extraction type of steam turbine arranged to bleed steam at 20 to 30 lb. for heating the mill, etc.

It would seem, therefore, that there is going to be very severe competition indeed in Lancashire before long between the steam-turbine builder and the steam-engine builder, and the fight will react to the good of both the Lancashire cotton industry and the whole of Great Britain generally from the point of view of national fuel economy.

The Operating Engineer and the Consulting Engineer

The relations between the operating and the consulting engineer appear to be subject to occasional stress in England as they are with us. The following sensible discussion of the subject is reproduced from *The Power User:*

The matter resolves into a question of the mentality of the two classes of engineer. Consulting engineers are apt to consider that when once a plant is designed and started up, no further attention is required, or at least that no further engineering knowledge of great value is essential. Too much trust is often reposed in the alleged capabilities of automatic gear; it is forgotten that parts wear out, and that even if high efficiency is obtained at first, it requires care and a wide knowledge of the plant to maintain the same degree of economy in every-day operation afterwards. An efficient engineer-in-charge must be thoroughly familiar with every detail of the principles and practical aspects of his plant in order to diagnose the causes of troubles and to keep it running reliably and economically. A man of smaller knowledge in charge of a plant may succeed in keeping it running somehow for a longer or shorter period, but he will not be qualified, either in the matter of technical knowledge or in the control of his staff, to maintain good conditions. The short-sighted policy of appointing such a man as engineer-in-charge has been proved repeatedly to be disastrous.

The engineer-in-charge, on the other hand, also often fails to see any good points in his consultant colleagues. He considers that he is capable of appreciating the conditions of his plant well enough to specify and plan extensions or, if necessary, drastic alterations. He is exasperated that his employers should consider it necessary to call in outside advice, and if the consultant be overbearing or contemptuous, the engineer-in-charge has nothing but scorn for his interference. Now, however good an engineer may be in the operation of his particular plant, in the knowledge gained from past experience with other plants and in his executive ability, his horizon is necessarily bounded to a considerable degree by the local conditions of his plant and

the detail of his every-day work. It is difficult for him to gain any comprehensive knowledge of what is going on elsewhere, except by unremitting technical reading and by the membership of technical associations. The consultant is called in generally because it is considered that he has greater opportunities to become familiar with up-to-date practice and has already shown that, by his methods of planning or reorganizing plants, he can effect economies.

To some extent at least the engineer-in-charge considers the consultant's reputation is ill-founded, and it must be confessed in reality he does not have much greater opportunity of seeing other people's work than does the engineer-in-charge. This arises from the fact that he is generally kept busy on work in hand and that there is no great amount of cooperation between consultants in any particular line.

Both types of engineer are invaluable to industry and each should recognize the other's good points. The engineer-in-charge, if he is a good man, will welcome a consultant's suggestions and give them very close attention. If he finds them fallacious he must, of course, refute the arguments used to the best of his ability, and his employer should give him credit for so doing rather than imagine that he is in all cases actuated by petty spite. Similarly, the consultant should work with the engineer-in-charge, whose local knowledge he will find of the utmost value. The consultant gains by the criticism or support of the engineer-in-charge and should be prepared to prove his case to the satisfaction of the latter. If he cannot, then it is at least questionable whether his advice is wholly sound and generally a second opinion will be desirable. If both parties in a case of this sort "consulted" together and agreed upon recommendations there would be no cause for ill-feeling and employers would be sure to obtain the best results possible.

Science to Be Popularized in a Home of Its Own in Washington

A magnificent building with an unusually interesting purpose is to be put up in Washington. It will house the National Academy of Sciences and the National Research Council, and so can properly be called the home of American science; but the more interesting feature is the educational object of the structure, which will be accomplished on a grand scale.

On passing through the entrance hall the visitor will find himself in a lofty rotunda, where he will see in actual operation apparatus demonstrating certain fundamental scientific facts that hitherto he has had to take on hearsay. A coelostat telescope, mounted on the dome of the central rotunda, will form a large image of the sun on the white surface of a circular table in the middle of the room. Here visitors will be able to see the sun-spots, changing in number and form from day to day, and moving across the disk as the sun turns on its axis. A 60-ft. pendulum, suspended from the center of the dome, will be set swinging through a long arc, repeating the celebrated experiment of Foucault. The swinging pendulum will mark an invariable direction in space, and as the earth and the building rotate beneath it, their rotation will be plainly shown by the steady change in direction of the pendulum's swing in relation to the building.

Two great phenomena of nature, the sun and the rotation of the earth, are thus to be exhibited. Other phenomena to be demonstrated in striking form in the central rotunda are magnetic storms, earthquakes, gravitational pull of small masses, the pressure of light, the visible growth of plants, swimming infusoria in a drop of ditch water, living bacteria and other interesting phenomena.

In the seven exhibition rooms surrounding the central rotunda, the latest results of scientific and industrial research will be illustrated. One room will be set aside for the use of Government bureaus, another for industrial research laboratories, others for the laboratories, observatories and research institutes of universities and other institutions. The newest discoveries and advances in the mathematical, physical and biological sciences and their applications will be shown in this living museum, whose exhibits will be constantly changing with the progress of science.

The building is to be of marble, in simple classical style, rising three stories from a broad terrace, with a frontage of 260 ft. It will contain an auditorium for 600 people, a lecture hall for 250, a reading room, a library, conference rooms, exhibition halls, etc. The architect is Bertram Grosvenor Goodhue, of New York. The construction work will be done by Chas. T. Wills, Inc., New York. Lee Laurie, the sculptor, will provide suitable decorations symbolizing the progress of science. The building will be the gift of the Carnegie Corporation of New York; the ground was bought for about $200,000, which was raised through about twenty donations. It is expected that the structure will be completed by the autumn of 1923, and will cost $1,300,000.

Characteristics of Petroleum Oils for Diesel Engines

At the April meeting of the Diesel Engine Users Association, London, England, Harold Moore read a paper on "Some Characteristics of Petroleum Oils Used on Diesel Engines." He referred to the various tests carried out on fuel oils and explained the bearing of these tests on the behavior of oils in the engines. In this manner specific gravity, flash point, viscosity, cold test, heat value, ultimate composition, sulphur content, spontaneous-ignition temperature, ash content, mechanical impurities, water content and Engler distillation were dealt with.

With regard to coke, soft asphaltum and hard asphaltum contents, the author explained that the three tests were closely interrelated, though the results of the tests were by no means identical. Soft asphaltum was defined as that portion of the oil that is insoluble in a mixture of alcohol and ether, while the hard asphaltum is the portion that is insoluble in light petroleum spirit. The coke value was usually lower than the soft-asphaltum value, but not always so. The total-asphaltum test was no criterion of the quality of the fuel oil, as Mr. Moore had found that it was really the hard asphaltum that caused the trouble in internal-combustion engines or some constituent of the hard asphaltum.

The author referred to the numerous special tests that were occasionally used in examining petroleum oils and suggested that for the purpose of commercial testing of fuel oils a much shorter series could be employed. These tests having been carried out, the subsequent behavior of the oils on engines was then largely dependent upon the speed of the engine, the compression pressure, the maximum m.e.p. at which the engine would run, and the type of injection used—that is, whether compressed air or mechanical.

The Queenston-Chippawa hydro-electric development of the Hydro-Electric Power Commission of Ontario is going to be investigated by a Royal commission that has been appointed by the Ontario government. The commission is empowered also to investigate any other power development of the Hydro-Electric Power Commission. The scope of the investigation is to be wide, and is to cover the cost and the method of the construction and operation of the plant.

Bursting of the Shaeffer Dam on Beaver Creek, Col., and the resulting Pueblo flood of last June have started litigation that may have a far-reaching effect. The Beaver Water and Irrigation Co. has filed suits for damages totaling $450,000 against the Arkansas Railway, Light and Power Co., and is being sued by a number of property owners. The latter claim that the bursting of the dam was due to faulty construction and improper care.

The ammonia generator should have a relief valve, and if the stop valve between the generator and exchanger cannot be locked open, the exchanger should also be provided with an ammonia relief valve, or the aqua ammonia circulating-pump discharge pipe should have a relief valve connected to discharge into the pump suction pipe or into the atmosphere.—*From a bulletin of the Hartford Steam Boiler Inspection and Insurance Co.*

News in the Field of Power

England Planning World Power Conference

A World Power Conference to be held in London in 1924 at the British Empire Exhibition is being promoted by the British Electrical and Allied Manufacturers' Association, in co-operation with manufacturers' associations and scientific, technical and similar organizations in Great Britain and other countries.

The executive council of the British Empire Exhibition has given permission for holding the conference at the Exhibition at Wembley in the spring or early summer of 1924 and has also agreed to provide a conference hall. The organizing director is D. N. Dunlop, director of the British Electrical and Allied Manufacturers' Association, Inc., 36, Kingsway, London, W. C. 2.

Present plans provide for holding the conference in four sections. One would deal with potential power resources; a second, with the engineering and other considerations in the development of power; a third, with the applications of power to agriculture, to industry, and in the central station; a fourth, with the economic and financial aspects of power.

One of the objects of the conference will be to discuss the possibility of establishing a permanent world bureau for the collection of data on the world's resources, and for the exchange of industrial and scientific information through appointed representatives in the various countries. Another object will be to find some means of utilizing the great number of engineers and workmen who, it is declared, will be thrown out of employment by reduction in the building of armaments.

Diesels for Abbeville, Louisiana

Abbeville, among the oldest towns in Louisiana, is to have a new central station to meet its pressing needs for more light, water and power. The city has had no street lights because of insufficient power, and has been penalized heavily by the Fire Underwriters because of inadequate water-pumping equipment.

A bond issue of $125,000 was authorized to finance the work, and all the necessary machinery has been purchased. Three 3-cylinder Fulton Diesel oil engines, developing 175 b.hp. each, will be installed, with direct-connected generators and exciters. The pumping equipment will consist of two 1,000-g.p.m. Dayton-Dowd Underwriters' fire pumps and two 300-g.p.m. domestic service pumps, all motor-driven. The water will be pumped from deep wells by the air-lift system with two slow-speed air compressors, also electrically driven.

L. E. Strothman Dies

L. E. Strothman, whose last active work was as vice-president and general manager of the Richardson-Phenix Co., died a few days ago. He was prominent in the American Society of Mechanical

LOUIS E. STROTHMAN

Engineers, having been a member of the society's Main Committee on Power Test Codes, chairman of the individual committee on reciprocating displacement pumps and vice-president of the society. He was also a member of the American Society of Civil Engineers, the American Water Works Association and the National Association of Stationary Engineers. In 1916-17 he was president of the Engineers Society of Milwaukee.

He was born in 1879 in Milwaukee, Wis., was educated in the Milwaukee Public Schools and in St. John's Military Academy, and went to work in 1893, serving as a draftsman with the Filer & Stowell Co., the Vilter Manufacturing Co., and the Nordberg Manufacturing Co. successively.

In 1902 he joined the Allis-Chalmers Manufacturing Co., serving in various capacities until 1919, when he became vice president and general manager of the Richardson-Phenix Co.

PROFESSOR STUMPF (right), the well known German engineer, and inventor of the unaflow steam engine, greeted at the pier by C. C. Trump, vice president of the Stumpf Unaflow Engine Co. (American representatives). The professor arrived May 5 to deliver a paper before the spring meeting of the American Society of Mechanical Engineers at Atlanta, and will spend some time here visiting the various American licensees of his engine.

Representative Bland Argues for his Coal Fact-Finding Bill

In his report on his bill creating a Coal Investigation Agency, Representative Bland points out that existing Government agencies are without detailed information as to various factors in the coal situation and that "no remedy for the situation can be applied nor can the wage controversy be permanently or justly settled except after all the facts concerning the industry are not only obtained but are tabulated and presented in a carefully and scientifically prepared manner." He believes that the bill, if enacted, will enable the agency to obtain facts "upon which proper legislative or executive action may be taken for all the purposes assigned in the bill."

"The agency has no administrative power except to obtain facts, does not purport to regulate, control or influence the industry in any way, and in any event cannot fall within the class of cases where regulation is denied the government to matters purely intrastate," he continues, after reviewing the hearings before the committee and the various features of the proposed legislation. He says the constitutional basis for the legislation does not rest on the power of Congress to regulate interstate commerce, but that it rests upon the constitutional power to obtain information as the basis for legislation. "The Constitution grants the power to legislate, and this grant necessarily implies that Congress has the right to obtain information necessary in performing the legislative function."

"The production of coal in the states for State use is inseparable from its production for interstate use, and it has been repeatedly held by the Supreme Court that where a matter may be inquired into or regulated by the Government as interstate, but which is closely connected with matters purely intrastate and are inseparable that the right to inquire into the matters intrastate could not be denied," he concludes.

Government Cuts Power Costs

In a report to Congress on Government economies during the year, the Budget Bureau says that there has been a saving of $40,000 in expenditures by the Federal Power Commission.

At the Edgewood, Md., arsenal of

the Chemical Warfare Service, there has been a saving of $261,215 by developing more economical operation of the power plant. Economy in this case is shown in the pounds of steam evaporated per pound of coal burned as follows:

March, 1920, 6.61 lb.; March, 1921, 8.48 lb.

April, 1920, 7.34 lb.; April, 1921, 8.66 lb.

May, 1920, 7.17 lb.; May, 1921, 9.22 lb.

June, 1920, 9.15 lb.; June, 1921, 9.345 lb.

The report states that in this and other ways the cost of power has been reduced to 1.8c. per kilowatt-hour.

In the State, War and Navy Buildings at Washington the heating systems were connected, saving salaries of firemen and expense for coal. Flow meters were installed to control the supply of steam in certain buildings, producing another saving.

Leather Belting Manufacturers Co-operate in Research

An example of what may be done through co-operation among competing business houses in the way of carrying on research work of value to all of them is to be found in the leather-belting industry. The manufacturers connected with the Leather Belting Exchange, which has offices in the Forrest Building in Philadelphia (Louis W. Arny, Secretary), realized the desirability of carrying on research with more elaborate facilities than would be justified on the part of any individual manufacturer, and accordingly established a research department, known as the Leather Belting Exchange Foundation, which is located at Cornell University and operated under the general direction of the officers of the Sibley College of Mechanical Engineering.

A completely equipped laboratory has been set up at the college in charge of R. F. Jones, research director, and it is reported that important information is resulting from the experiments that are being conducted there.

The apparatus at the laboratory consists principally of two 100-hp. electric dynamometers, either of which may be used to drive the other in either direction through the belt that is being tested. One machine can be moved along carefully leveled tracks to accommodate belts of varying lengths, and arrangement is made for measuring the center-to-center distance within 0.005 inch. Means are also provided for measuring accurately the pull of the belt on each side, the torque of the shafts, the revolutions per minute, the slip of the belt, the sag of the belt halfway between the pulleys, etc.

The work of the laboratory will be directed toward the working out of two kinds of information—relating to the manufacture of belting, and to its use. The service, therefore, is a double one, benefiting both those who make belting and those who use it. These investigations, it is reported, have already produced a better understanding of the whole subject by both manufacturers and consumers and have also brought about a material improvement in the quality of the product.

New Publications

Steam Pipes. Published by the Vulcan Boiler & General Insurance Co., Ltd., 67 King St., Manchester, England. Paper, 5½ x 8½ in., 108 pages. Price 1 shilling net.

A collection of notes prepared by one of the company's assistant engineers under the direction of Chief C. Bullock, dealing with various kinds of valves and other piping accessories of English manufacture, and with practical problems in installing and maintaining steam-pipe lines.

Steam Power Plant Auxiliaries and Accessories. Edtied by Terrell Croft, consulting engineer and directing engineer, Terrell Croft Engineering Co. Published (1922) by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Cloth; 5½ x 8 in.; 447 pages; 402 illustrations; 63 numerical problems with answers. Price, $3 postpaid.

The particular genius of the Terrell Croft organization seems to lie in the ability to explain engineering facts in a manner easily understood by any intelligent person. This book is a good example of what can be done along this line by working at all times in accordance with the principles of skillful teaching. Some engineers whose technical ability is of the highest grade are totally lacking in teaching instinct and ability. They are able to handle practically any engineering problem themselves, but when they put it in book form for the benefit of other people the result is a dry-as-dust (although accurate) treatise, which is of little use to the average engineer. The engineering author with the teaching idea, on the other hand, feels that being accurate and complete is only half of his job. The other half is to make each essential point stand out so clearly that the reader cannot fail to understand it. This volume is an ideal example of the latter method, not only in its text, but in the arrangement, the illustrations and the use of a large number of practical numerical problems, the answers of which are given in the back of the book.

The thirteen main divisions of the book are as follows: Pump calculations; direct-acting steam pumps; crank-action pumps; centrifugal and rotary pumps; injectors; boiler-feeding apparatus; feed-water heaters; fuel economizers; condensers; methods of recooling condensing water; steam piping of power plants; live-steam and exhaust-steam separators; steam traps.

There is hardly anyone who has to do with these subjects who would not find this book of decided assistance, whether his main interest be practical or theoretical, and whether or not he has had extended experience with such apparatus.

The Engineering Index for 1921. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Cloth; 9½ x 6½ in.; 584 pages.

A valuable guide to engineering literature, containing over 14,000 references to about 600 publications, arranged alphabetically. Each reference gives: the exact title of the article; the author; the publication; the volume, number and date; the page numbers and number of figures in the article; and a brief summary of the article. Cross-references are a further aid. The Society publishes these volumes every year, and in preparing the present one its engineering staff reviewed about 1,200 periodicals, printed in ten different languages.

Personals

John W. Armitage has taken a position as chief engineer and master mechanic of the Jacob Miller Sons & Co. plant in Philadelphia.

Charles E. Cansfield has left the Toronto and Niagara Power Co. to open an office in Toronto as a consulting electrical engineer.

George R. Warner, formerly chief engineer of the American Express Building at 65 Broadway, New York City, has been appointed general manager for the Stock Exchange Building Corporation, 18 Broad St., New York City. The appointment will take effect June 1.

Louis Resnick has left his position as editor of the *National Safety News* and director of publicity for the National Safety Council to open offices of his own in New York City as editorial and publicity counsel. His place as editor of the *News* is taken by George Earl Wallis.

August Krohne, for twenty-five years treasurer of Jersey City Association, N.A.S.E., was given a testimonial dinner and "send-off" a few days before sailing for Germany on May 8 for a four months' trip. He was an engineer with the Jersey City Printing Co. for more than twenty years. The toastmaster was John Calahan, past national president, who joined the order with Mr. Krohne in 1898. There were speakers and an entertainment program, and Mr. Krohne was presented with a traveling bag and a cigar holder.

W. W. Schwarting, recently in the Minneapolis office of the Westinghouse Electric and Manufacturing Co. as a sales engineer, has been made superintendent of the Water and Light Depart of Hibbing, Minn. He was graduated from Iowa State College in 1905 and was with the Westinghouse Co. until 1920, when he left to become assistant to the general superintendent in charge of central power station

operation for the Peoples Power Co., Rock Island, Ill. He was general superintendent of that company from 1917 until his association with the Westinghouse company a few years ago.

Harry W. Osgood has joined the engineering department of the recently organized firm of McClelland & Junkersfeld, Inc., New York City, as an electrical engineer. He has had a wide experience in the design and construction of power plants and distribution systems in the course of fourteen years of service with Stone & Webster.

Society Affairs

Coming Conventions

American Water Works Association, 153 West 71st St., New York City. Annual convention at Philadelphia, May 15-19.

National Electric Light Association, 29 West 39th St., New York City. Annual convention at Atlantic City, N. J., May 15-20.

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Annual convention at Buckwood Inn, Shawnee-on-Delaware, Pa., June 5-7.

American Order of Steam Engineers; Andrew Lauterbach, 4726 North Warnock St., Philadelphia, Pa. Annual convention and exhibition at Philadelphia, June 5-9.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Semiannual meeting at Groton Pt., Conn., June 19-21.

National District Heating Association; D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West, Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

New Jersey, at Elizabeth, June 2-4; E. J. Flynn, 423 Newpoint Road, Elizabeth, N. J.

Illinois, at Chicago, June 7-10; I. S. Pieters, 1130 Clay St., Chicago.

New York, at New York City, June 8-10; T. J. Condon, 102 Seventh Ave., New York City.

Indiana, at Anderson, June 9-10; Frederick L. Ray, Anderson, Ind.

New England, at Springfield, Mass., July 12-14; James Morgan, 53 Devonshire St., Boston.

Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

Rochester Section, A. S. M. E., is to meet May 19 to hear a talk on "Engineering and Citizenship" by President Kimball.

The Associated Technical Societies of Detroit will meet May 19 under the auspices of the Chemists for a lecture on "Nitrogen Fixation, Especially in Relation to the Work at Muscle Shoals," by Prof. R. F. Tour, of the University of Cincinnati, who was in charge of the nitrogen plants during the war.

The Engineering Society of Western Massachusetts, at its annual dinner meeting at 6:30 p.m., May 16, at the Hotel Kimball, Springfield, Mass., will hear the Einstein Theory explained by Dr. Charles P. Steinmetz, "The Wizard of Electricity." Those in charge of the program, however, have thoughtfully provided an additional speech by Rev. James Gordon Gilkey on "The Lighter Side of Engineering."

Business Items

The Springfield Boiler Co. has announced the establishment by F. E. Van Hoesen of an engineering sales office in the Kirby Bldg., Cleveland. He will represent the company in the sale of water-tube boilers in northern and central Ohio, and will also represent the Ohio Machine and Boiler Co., of Cleveland, in the sale of return-tubular boilers.

Hadlow, Hick & Co., Finance Bldg., 750 Prospect Ave., Cleveland, Ohio, has been formed by H. Ralph Hadlow and Noel H. Hick, who were formerly vice-president and general manager, and director and engineer in charge of building design, respectively, with The Watson Engineering Co. They will engage in the design, supervision and construction of power plants and other buildings.

The Elliott Co., Jeannette, Pa., has promoted W. E. Widau, formerly in the Cleveland office, to be assistant general sales manager in the main office, and has appointed J. R. Lemon and S. B. Overton to its sales force in Philadelphia, R. K. Williams in Cleveland and W. T. Bickel in Pittsburgh. In addition to Elliott products these men will sell also for the Liberty Manufacturing Company, of Pittsburgh, and the Lagonda Manufacturing Company, of Springfield, Ohio.

H. M. Haven and A. T. Hopkins incorporated recently as consulting engineers and industrial managers. The firm was formerly H. M. Haven & Wm. W. Crosby, Inc., 40 Court St., Boston, Mass., the new firm having been organized shortly after the death of Mr. Crosby. Mr. Hopkins was in charge of the reorganization and rebuilding of the Cleveland, Ohio, plant of the United States Rubber Co. from 1912 to 1917, and was industrial engineer for the company from then until his recent association with Mr. Haven. Both are graduates of the Massachusetts Institute of Technology.

The Pelton Waterwheel Co., of San Francisco and New York, has made formal announcement of its purchase by the William Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa. A preliminary announcement of the change was published in *Power* for March 7. The Pelton company retains its identity and will continue in business under the same name as before. Its New York office will be continued, although the address has been changed to 100 Broadway, the same as for the Cramp company. The San Francisco office will be continued at 19th and Harrison Sts. New executives have been selected, including William M. Moody, second vice-president; he is a younger brother of Louis F. Moody, who remains in Philadelphia with the Cramp company.

Trade Catalogs

Regulators — Ruggles-Klingemann Manufacturing Co., Salem, Mass. A short bulletin on damper and fan engine regulators, adjustable chronometer valves, temperature control regulators and similar devices.

Steel Belt Conveyors—Sandvik Steel, Inc., Woolworth Bldg., 233 Broadway, New York City. A 26-page booklet on Sandvik steel belts, which are made in one-piece lengths of 250 to 325 ft., and are used for conveying many different kinds of material in various industries.

Motor Drive and Control—Sprague Electric Works of the General Electric Co., 527 West 34th St., New York City, Bulletin No. 48,717, "Sprague System Electric Motor Drive and Control for Newspaper Presses," dealing particularly with the power problems of the pressroom.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	May 1, 1922	May 8, 1922
Pool 1,	New York	$3.75	$3.50@4.00
Smokeless,	Columbus	2.15	2.25@2.50
Clearfield,	Boston	2.60	3.00@3.25
Somerset,	Boston	2.80	3.15@3.60
Kanawha,	Columbus	2.65	2.50@2.75
Hocking,	Columbus	2.90	2.75@3.00
Pittsburgh No. 8	Cleveland	2.90	2.85@3.10
Franklin, Ill.,	Chicago	3.00	2.75@3.25
Central, Ill.,	Chicago	2.75	2.60@2.85
Ind. 4th Vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	2.75	.....
West Ky.,	Louisville	2.60	2.50@2.75
Big Seam,	Birmingham	1.70	1.50@1.90
S. E. Ky.,	Louisville	2.75	2.75@2.85

FUEL OIL

New York—May 10, Port Arthur light oil 22@25 deg. Baumé 3¼c. per gal.; 30@35 deg., 4¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—Apr. 5, for 24@28 deg. Baumé, 85@90c. per bbl.; 21@36 deg., 2⅜@2½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Apr. 25, f.o.b. refinery, Pennsylvania, 36@40 deg. 4¾c. Kentucky fuel oil, 26@30 deg., 3c. per gal. Western, 24@30 deg., 85c. per bbl.; 32@34 deg., 3c. 36@38 deg., 3¼c. 38@40 deg., 3½c. per gal.

St. Louis—Mar. 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90c. per bbl.; 26@28 deg., 95c.; 28@30 deg., $1.10; 32@34 deg. 2½c. per gal.

Philadelphia—May 10, 26@28 deg. Baumé, Oklahoma, 75@80c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅜@2¾c. per gal.; 16@20 deg. Seaboard, $1.10@$1.25 per bbl.

Cincinnati—Apr. 25, for 26@28 deg. Baumé, 4½c.; Diesel 32@36 deg., 4¾c. per gal.; distillate 38@48 deg., 5½c.

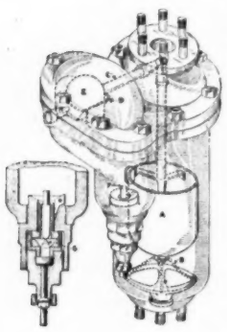
Cleveland — Apr. 25, 26@30 deg. Baumé, 3½c. per gal.

Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Regulator, Guardian Fuel Oil "Power," 1922.

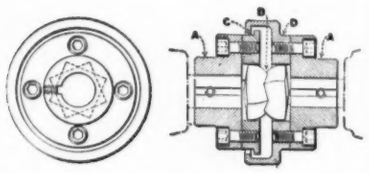
White Fuel Oil Engineering Co., 742 E. 12th St., New York City



A safety device for shutting off the oil supply to an oil-fired boiler furnace when the water level in the boiler gets dangerously low. It is shown at the right in the illustration. It is placed at the same level as the gage glass, the steam connection being at the top and the water connection at the bottom. When the water level falls to a point previously decided upon as being dangerous, the hollow float *A*, which is full of water, pulls harder on the vertical rod to which it is attached, and so, through a crank, turns the short rod *C*, tips the cradle *D*, and thus lets the ball *E* roll out and drop. The ball strikes the ram head *F*, a larger view of which is shown at the left. On the bottom end of this ram is a peculiar-shaped point *G*, which perforates a copper disc, thus allowing steam to enter a special valve (not shown) which shuts off the fuel supply. Described further on page 97 of "Power" for Jan. 17, 1922.

Coupling, Whitney Free-Floating "Power," 1922.

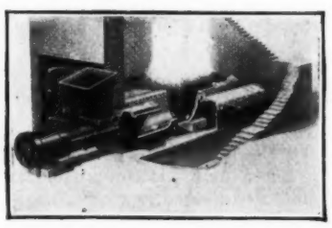
Kay Manufacturing Co., Norwalk, Conn.



A free-floating flexible coupling so designed that the coupling element can be removed without disturbing either one of the two shafts that are connected. It consists of two hubs *AA*, which are keyed to the shaft; a peculiar-shaped link *B*, which is the actual connection between the shafts; an inner ring *C* and an outer ring *D*. Both rings are held to the hubs by capscrews. Each end of the link *B* has a square cross-section, and the corners of the two halves are staggered, as shown in the view at the left. The two ends fit into square holes in the rings *C* and *D*, in this way transmitting the power. By taking out the capscrews, the two rings and the link can be lifted right out, and if necessary, the hubs also can be removed. Described further in "Power" for Jan. 31, 1922, page 186.

Stoker, Jones Side-Dump "Power," 1922.

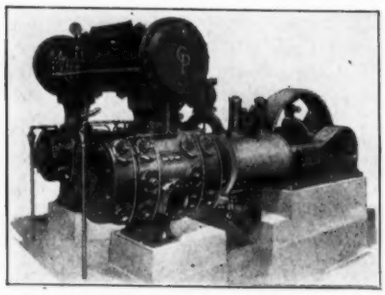
Underfeed Stoker Co. of America, Book Bldg., Detroit, Mich.



This stoker differs from the Jones "Standard" stoker in that sloping combustion grates are used instead of the hand-cleaned dead plates, and a hand-operated dump plate on either side is provided for dropping the ash into the ashpit. Depending on local conditions, the ashpits extend only 6 to 18 in. below the floor line, so that installation under new or established boilers is comparatively simple. The stoker is self-cleaning and may be driven by steam, motor or lineshaft. To turn a Jones "Standard" into a side-dump stoker means changing the tuyeres, replacing the dead plates with combustion grates and adding dump plates. Further described in "Power" for Jan. 24, 1922, page 146.

Compressor, Air, Dual-Flow Steam-Driven "Power," 1922.

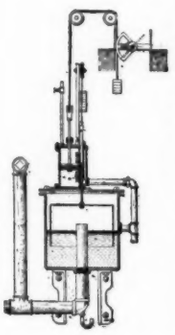
Chicago Pneumatic Tool Co., 6 East 44th St., New York City.



The steam end of this compressor is designed on the unaflow principle, the exhaust leaving through a port, in the center of the cylinder, that is covered and uncovered by the piston. The exhaust is further controlled by a poppet valve that opens when the piston is near the end of the stroke. The steam and exhaust valves are of the double-seat poppet type. Regulation is effected by two-step capacity control; two differential unloaders connect with the inlet valves and reduce the capacity of the compressor in two steps. The air valves are of the "simplate" independent disc type. Described more fully in "Power" for Feb. 14, 1922, page 265.

Regulator, Damper "Power," 1922.

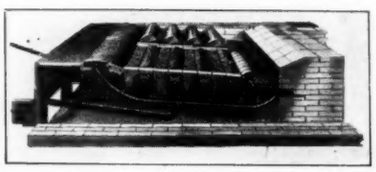
Craig Damper Regulator Co., Detroit, Mich.



Draft-operated regulator controlling the position of the damper according to the pressure or vacuum in the boiler furnace. The pipe at the left connects the inside of the furnace with the inside of a bell float. The float is connected to a small piston valve in one side of the cylinder on top of the float container. Into the top of this cylinder, at the left, water is admitted through a small pipe, filling the space above the piston. A series of ports at the side of the cylinder allow this water to escape as long as the piston valve attached to the float is in an upper position; but when this piston valve is lowered by a decrease in pressure inside the bell float, the escape of the water is cut off, and the hydraulic pressure forces the piston downward. This downward motion, by means of the chain and pulley arrangement shown, shuts off the damper somewhat, and so tends to restore the predetermined pressure or vacuum in the furnace. Further described in "Power" for Feb. 28, 1922, page 334.

Stoker, Auburn Hand "Power," 1922.

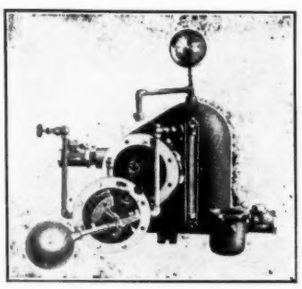
Marion Foundry Corporation, Auburn, Ind.



A new hand stoker requiring little incline for successful operation, and therefore no excavation for the ashpit. It is made up of a curved coking plate at the front, alternate moving and stationary elements in the grate proper and a cutoff dump plate at the rear. Coal is piled up on the curved coking plate and is carried back toward the rear of the furnace by the moving element, one full movement of which pushes the entire fuel bed 6 in. to the rear. The stoker is divided into two longitudinal sections; in one of these sections, in the illustration, the moving elements are shown advanced to one-half full stroke. A separate lever at the furnace front operates the dump plate, and moving elements are counterbalanced to make operation easy. Described further in "Power" for Jan. 17, 1922, page 101.

Trap, Wilmon Vacuum "Power," 1922.

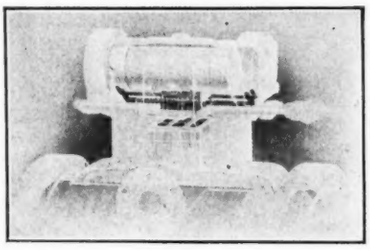
P. H. Gill & Sons Forge and Machine Works, Brooklyn, N. Y.



With the exception of the cover bolts this trap has but thirteen parts, and by removing the capbolts, the working mechanism, mounted on a flange, can be taken out as a unit. The receiving chamber of the trap is under vacuum when the water is collecting and under atmospheric pressure during discharge. Back flow is prevented by check valves on the inlet and outlet lines. The capacity of the trap is limited only by the size of the inlet and outlet opening. A two-inch model, for instance, handles 1,800 to 2,100 gallons of water an hour, the capacity varying according to the lift of the discharge. Described on page 99 of "Power," Jan. 17, 1922.

Valve Gear, Pump "Power," 1922.

Warren Steam Pump Co., Warren, Mass.



A lever is mounted on a fulcrum pin held by a pedestal. At its lower end it is connected to the piston-rod, and near its top is a tappet, which moves between two tappet collars mounted on the valve rod. These communicate the action of the pump rod to the valve rod. This rod is connected inside of the steam chest to the valve yoke, which is set over the stem of the main slide valve and through its full travel carries with it the auxiliary valve, which is set at one side. Toward the end of the movement of the yoke it is brought in contact with the stem of the main slide valve, slowly moving it until the auxiliary valve operates the valve-driving piston. Described further in "Power" for Jan. 17, 1922, page 90.

Clip, paste on 3 x 5-in. cards and file as desired

New Plant Construction

PROPOSED WORK

Cal., Oakland—The Oakland City School Dist., Pacific Bldg., is having plans prepared for a 2 story vocational high school on 26th and Filbert Sts. About $385,000. C. W. Dickey, 357 12th St., and J. J. Donovan, Associates, Archts.

Cal., Sacramento—The California State Life Ins. Co., Forum Bldg., is having preliminary plans prepared for an 8 or 10 story office building on 10th and J Sts. About $1,000,000. E. C. Hemmings, Ocshner Bldg., Archt.

Cal., Sacramento—The city is having plans prepared for a high school. About $750,000. E. A. Mathews, Call Bldg., San Francisco, Archt.

Colo., Denver—The Chicago, Burlington & Quincy R.R. shops, F. T. Darrow, Asst. Chief Engr., Lincoln, Neb., plans to install an additional 150 hp. boiler and stoker.

Conn., Hartford—The High School Plant and Bldg. Committee is having plans prepared for a 3 story high school on Maple Ave. About $1,500,000. E. T. Wiley, 75 Pratt St., Archt.

Conn., New Haven—Starrett & Van Vleck, Archts., 8 West 40th St., New York City, are receiving bids for a 5 story, 70 x 130 ft. department store including a steam vacuum system on Chapel St. for The Edward Malley Co., 898 Chapel St. Estimated cost $450,000.

D. C., Bellevue—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install air compressor in hospital here. Spec. 4622.

Fla., Moore Haven—The Bond Trustees will receive bids until May 26 for the construction of a 250,000 gal. filter unit with 50,000 gal. elevated tank, 5,000 lin.ft. 6 in. water mains. Pumping equipment consists of one 3 in. with electric plant pumping 180 gal. per min. 20 ft. head and one 3 in. electric driven pump, 100 ft. head, 180 gal. per min. C. E. Frederick, Engr.

Ill., Chicago—The Bd. Educ., 650 South Clark St., is having plans prepared for a 3 story addition to high school including a steam heating system on Union Ave. and 48th Sts. About $3,000,000. J. C. Christensen, 650 South Clark St., Archt.

Ill., Chicago—The Bd. Educ., 650 South Clark St., is having plans prepared for an addition to high school on Milwaukee and Addison Sts. About $1,500,000. Also a 3 story high school on Harrison and Plymouth Sts. About $750,000. Plans include steam heating systems. J. C. Christensen, 650 South Clark St., Archt.

Ill., Chicago—E. E. Hall, Archt., 123 West Madison St., is preparing plans for a 4 story, 195 x 215 ft. apartment including a steam heating system on Yates, Phillips and East 72nd Sts. About $2,000,000. Owner's name withheld.

Ill., Chicago—E. M. Heller & Co., 144 West Kinzie St., is in the market for a 10 ton York Ammonia compressor with or without condenser and coils, single drum, 6,000 lb. hoist, with 3 phase, 60 cycle, 440 volt motor, direct connected.

Ill., Chicago—Lowe & Bollenbacker, Archts., 108 South LaSalle St., are receiving bids for a 4 story, 125 x 140 ft. Y. M. C. A. building including a steam heating system on 53rd St. and Dorchester Ave. for the Y. M C. A. About $350,000. Noted March 14.

Ill., Chicago—P. F. Olsen, Archt., 127 North Dearborn St., will soon receive bids for a 3 story, 100 x 179 ft. apartment including a steam heating system on Pratt Blvd. near Ashland Ave. for J. Frohman. About $350,000.

Ill., Chicago—B. Steif & F. R. Seibold Jr., c/o B. L. Steif & Co., Archts., are having plans prepared for a 3 story, 140 x 225 ft. apartment including a steam heating system at 521-41 Wellington St. About $500,000.

Ill., Chicago—The Windemere Hotel Co., 1614 East 56th St., is having plans prepared for a 12 story, 182 x 360 ft. hotel including a steam heating system on East 56th St. About $2,000,000. Rapp & Rapp, 190 North State St., Archts.

Ill., Evanston—The Dearborn Building & Finance Co., 127 North Dearborn St., plans to build five apartments including a steam heating system on South Blvd. and Michigan Ave. About $1,000,000. Rissman & Hirschfield, 139 North Clark St., Chicago, Archts.

Ind., Ft. Wayne—The Lincoln Life Ins. Co., Lincoln Life Bldg., has had plans prepared for a 12 story, 275 x 330 ft. office building on Harrison Ave. About $2,000,000. B. W. Morris, 101 Park Ave., New York City, Archt. H. G. Balcom, 16 East 47th St., New York City, Engr.

Ind., Hammond—The Jones & Laughlin Co., Ross St., Pittsburgh, Pa., have purchased a site of 1,000 acres and plans to build a steel plant. Probably private plans.

La., Lafayette—J. C. Barry, W. A. Montgomery, P. Krauss, C. D. Caffery, W. D. Huff, M. E. Saucier and J. P. Colomb, have formed a local syndicate and offer to lease the water, light and sewerage and drainage plant of municipality for period of 22 years, at an annual rental of $5,000 conditioned on immediate installation of new machinery at estimated cost of $75,000. Proposition will be submitted to voters for approval.

La., Plaquemine—Swanson-McGraw, Inc., Engrs., 705 United Fruit Bldg., New Orleans, making survey of waterworks and electric light system with view of remodeling plant. About $150,000.

Me., Howland—The Penobscot River Co., Bangor, plans the construction of a hydro electric generating plant on the Rockabema River. About $125,000. Architect not announced.

Mich., Detroit—The Clifford Realty Co., R. M. Drysdale, Pres., 1026 Dime Bank Bldg., plans to build a 10 story, 100 x 102 ft. apartment hotel including a steam heating system and mechanical refrigeration equipment on Clifford and Duffield Sts. About $1,000,000. J. P. Jogerst, 55 Rowland Bldg., Archt.

Mich., Kalamazoo—The Bd. Educ. will receive bids until May 22 for furnishing and delivering one 150 kw. direct connected engine generator unit, one 285 hp. vertical water tube boiler with complete brick setting, one 75 kw. motor generator set, and one 285 hp. chain grate stoker. R. E. Parks & Son, 623 Michigan Trust Bldg., Grand Rapids, Engr.

Minn., Mankato—The Mankato Co-operative Dairy Assn., A. L. Veigel, Mgr., is in the market for ice cream machinery, including 15 ton ice machine, also 40 hp. boiler.

Mo., Paris—The city plans electric power plant and lighting system. About $75,000. W. B. Rollins & Co., 209 Railway Exchange Bldg., Kansas City, Engr.

Neb., Alliance—The Chicago, Burlington & Quincy R.R., Chicago, Ill., is having plans prepared for a 48 x 60 ft. power plant to house 4 250 hp. boilers, smoke stack 6 x 150 ft. Mechanical equipment to be installed for coal and ash handling. F. T. Darrow, Lincoln, Asst. Ch. Engr.

Neb., Lincoln—The Bd. Educ., J. G. Ludlam, Secy., 15th and N Sts., plans to build a school on 21st and Burr Sts. (1st unit). About $125,000. Total cost about $600,000. Fiske & Meginnis, Bankers Life Bldg., Archts.

Neb., McCook—Chicago, Burlington & Quincy R.R., W. T. Krausch, Engr. of Buildings, Chicago, plans to build a 48 x 60 ft. power plant, install 750 hp. dynamo and engine to replace 50 kw. generator, mechanical coal and ash handling machinery. F. T. Darrow, Lincoln, Asst. Ch. Engr.

N. J., Jersey City—The Bd. Educ. will soon receive bids for a 3 story school on Erie St. About $500,000. J. T. Rowland, 100 Sip Ave., Archt. and Engr.

N. J., Wildwood—H. M. Moffett, Archt., 531 Market St., Camden, plans to build a 6 story, 110 x 115 ft. hotel and apartment building. About $500,000. Owner's name withheld.

N. Y., Batavia—The City voted $450,000 bonds for the construction of a high school. Address R. F. Clark, City Engr.

N. Y., Binghamton—The Bd. Estimate and Appointment and Common Council, having plans prepared for a new First Ward School. About $365,000. E. H. Bartoo, 84 Court St., and E. W. Dickerman, 84 Court St., Archts.

N. Y., Brooklyn—The Brooklyn State Hospital for Insane, Clarkson Ave., receive bids for the construction of a hospital from the W. W. Construction Co., 51 East 42nd St., New York City, $298,000; Putnam Construction Co., 303 5th Ave., New York City, $314,000; and the Vought Constr. Co., 131 East 44th St., $319,500. Heating, from Chute, Thornton & Bayley Corp., 153 East 42nd St., $26,998; Austin Engr. Co., 121 West 42nd St., New York City, $27,872; E. W. Thompkins & Co., Albany, $28,275. Noted April 11.

N. Y., Brooklyn—The Five Star Shoe Co., 33 Marcy Ave., is in the market for a small electric driven pump.

N. Y., Brooklyn—S. C. Morris, 105 Liberty St., is in the market for a 50 or 60 hp. boiler economic or locomotive type, 100 lbs. capacity.

N. Y., Buffalo—The Cleveland Cold Drawn Steel Co., C. H. Hopkins, Secy.-Treas., 503 Leader News Bldg., plans to build a 1 story steel plant along the tracks of the South Buffalo R.R. About $1,000,000. Private plans.

N. Y., Buffalo—L. A. Maltby, 21 Maryland St., is in the market for a 20 hp. D.C. 110 volt motor, (new or used).

N. Y., Cortland—The city, J. R. French, Clk., plans election May 23 to vote $350,000 for new high school.

N. Y., Highland Park—Anderson & Cowie, c/o G. Kingsley, Archts., 109 North Dearborn St., Chicago, are having plans prepared for a 200 x 200 ft. hotel on Central Ave. Estimated cost $1,500,000.

N. Y., Hornell—The Erie R.R., 50 Church St., New York City, plans to build an addition to repair shops here. Cost between $200,000 and $225,000. Address J. Gravis, Asst. Div. Engr., Erie R.R., Hornell.

N. Y., Jamestown—G. F. Hurlbert, Pres. Hotel Samuels, Cherry and 3rd Sts., is having plans prepared for an 8 story, addition to hotel. Cost between $460,000 and $480,000. A. E. W. Schonenberg, Olean, Archt.

N. Y., New York—The Advertising Club of New York, 47 West 25th St., is having plans prepared for a 10 story club at 2-8 West 46th St. About $1,200,000. Helmle & Corbett, 132 West 42nd St., Archts. and Engrs.

N. Y., New York—The Bd. Educ., 500 Park Ave., plans to build a school on Franklin Ave. near 168th St. About $500,000. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., New York—The Crane Commercial Corp., 80 Wall St., is in the market for a gas engine 35-50 hp. standard make.

N. Y., New York—The Dept. Public Welfare, B. S. Coler, Comr., Municipal Bldg., will receive bids until May 18 for furnishing labor and material for repairs to hull, boiler and engine, also installing electric light plant in steamer T. M. Mulry.

N. Y., New York—M. M. Gleasen, c/o G. and E. Blum, Archts., 505 5th Ave., are having sketches made for a theatre and office on 23rd St. and 8th Ave. About $500,000.

N. Y., New York—The Shelton Holding Corp., 25 West 43rd St., is having plans prepared for a 30-story hotel on Lexington Ave. between 48th and 49th Sts. About $4,000,000. A. L. Harmon, 27 East 40th St., Archt. and Engr.

N. Y., Rochester—L. M. Randall, 354 Meiga St., is in the market for a medium size water tube boiler.

N. Y., Saranac Lake—The Chamber of Commerce, G. H. Gasely, plans to build a hotel. Estimated cost $700,000. Architect not announced.

N. C., Greensboro—The city Council has ordered construction of 1—Reedy Forks Dam—16,000 ft. long with spillway to form 1,000,000,000 gal. reservoir. Cost about $80,000; 2—Installation of hydro electric equipment, $20,000; 3—Erection of 6 filtering units, 1,000,000 gal. capacity, each $90,000. J. L. Ludlow, Winston Salem, Engr. Contracts will probably be let within the next 3 weeks. Noted April 11.

N. C., Mt. Airy—The city, C. M. Whitlock, Supt., City Hall, is receiving bids until about June 1st for waterworks improvements to include 26 x 26 x 8 ft. coagulating basin, 250,000 gal. filter unit complete; 25,000 gal. wash water tank on 30 ft. tower with 8 in. pipe raiser and one chlorinating apparatus. Bids wanted only on material and equipment, work will be done by city forces.

N. D., Dickinson—The city will receive bids until May 22 for one oil engine 25 hp. for water department and one double stroke deep well pump.

O., Cincinnati—The Provident Bank & Trust Co., 7th and Vine Sts., will soon award the contract for an 11 story, 63 x 95 ft. and 63 x 135 ft. office and bank building including a low pressure steam heating system on 7th St. About $500,000. H. Hake, Telephone Bldg., Archt.

O., Cincinnati—Rollman & Sons Co., 15th and Vine Sts., plans to build a 12 story, 100 x 125 ft. mercantile building including a steam heating system. A. Kahn, 1000 Marquette Bldg., Detroit, Archt.

O., Columbus—(Change of date)—The Bd. Educ., E. L. McCune, Clk., will receive bids until May 24 for a 2 story, 220 x 300 ft. high school. About $650,000. Richards, McCarty & Bulford, 584 East Broad St., Archts. Noted Jan. 31.

O., Dayton—The city plans to build a pumping station to supply water to Fairview and Mt. Huborn Water Dist. About $50,000. K. B. Allen, U. B. Bldg., Dayton, Engr.

Okla., Duncan—The City, J. F. Ewell, City Mgr., is having plans prepared for a municipal electric distribution system to be operated in connection with municipal plant now under construction. Estimated cost, $80,000. A. L. Mullergren, Gates Bldg., Kansas City, Mo., Consit. Engr.

Okla., Pawnee—The council will soon receive bids for improvements to present electric light plant. About $65,000. Benham Engr. Co., Kansas City, Mo., Consit. Engrs.

Pa., Erie—W. Bloeser, 142 East 12th St., is in the market for a good size air compressor.

Pa., Erie—The Erie Burial Casket Co., 20th and Peach Sts., is having plans prepared for a 2 story, 200 x 300 ft. casket factory along the tracks of the Pennsylvania R.R. between 8th and 10th Sts. Private plans. About $300,000.

Pa., Erie—J. A. Leslie, Controller Erie County, will receive bids until May 22 for the construction of addition and alterations to county court house. About $500,000. W. A. Frank, 11 Scott Bldg., Archt. Separate bids will be received for heating, ventilating, etc.

Pa., Phila.—The Bd. Educ., c/o A. Castle, 19th and Chestnut Sts., will soon receive bids for four elementary schools. Total cost about $1,070,000; and three junior high schools. Total cost about $1,865,000. Private plans.

Pa., Phila.—The city, c/o A. Holmes, City Hall, will soon receive bids for a 3 story building "Palace of Justice" on 21st St. and the Parkway. Total cost about $5,000,000. J. T. Windrin, Commonwealth Bldg., Archt.

Pa., Phila.—The city will soon receive bids for the construction of a pumping station, furnishing pumps, etc. E. A. Vogelson, City Hall, Engr.

Pa., Phila.—Magazmer, Eberhard & Richards, Archts., 603 Chestnut St., are receiving bids for an 8 story, 50 x 102 ft. shirt factory including a steam heating system at 121-25 North 8th St. for L. Lavenson & Son, 237 North 6th St.

Pa., Phila.—R. D. Wood & Co., 400 Chestnut St., is in the market for a horizontal duplex compound pump with condenser and equipment, 2,000,000 gal. per 24 hrs.

Pa., Phila.—The Y. M. C. A., c/o L. J. Obermayer, 1916 Erie Ave., plans to build a 5 story, 138 x 141 ft. Y. M. C. A. building including a steam heating system on Broad and Pine Sts. About $750,000. F. E. Hahn, 1112 Chestnut St., Archt.

Pa., Pittsburgh—The Bd. Educ., Fulton Bldg., is having plans prepared for a 2 story school on Hazelwood and Gladstone Sts. About $500,000. O. M. Topp, Jenkins Arcade, Archt.; 2 story junior high school on North Side. About $500,000. J. T. Steen & Son, Fulton Bldg., Archts.; 2 story addition to school on 10th and Carson Sts. About $500,000. E. Stotz, Monongahela Bldg., Archt.; 2 story school on Rockland St. About $500,000. P. C. Dowler, Magee Bldg., Archt.; 2 story addition to high school on Margeratte St. About $500,000. E. B. Lee, C. of C. Bldg., Archt.; and a 2 story school on Lydia and Farnsworth Sts. About $200,000. Private Plans.

Pa., Warren—The Bd. Educ. plans to build two high schools, cost between $500,000 and $750,000. Architect not selected.

Pa., Warren—The Warren Light & Power Co., plans to build an electric line to Youngsville. About $75,000.

Tenn., Knoxville — The Appalachian Marble Co., Middlebrook Pk., is in the market for an air compressor 300 to 500 cu.ft. capacity, motor or belt driven.

Wash., Seattle—The Real Estate Improvement Co., 815 2nd Ave., will soon receive bids for an 8 story, 120 x 128 ft. apartment including a vacuum steam heating system on 9th Ave. and Union St. About $825,000. S. D. Ford, Lyon Bldg., Archt.

W. Va., Fairmont—The Dattile Fruit Co. will soon award the contract for a 3 and 7 story, 68 x 70 ft. fruit warehouse on Cleveland Ave. About $40,000. Concrete Steel Engr. Co., 15 Park Row, New York City, Archts. Cold storage plant will be installed.

W. Va., Spencer—The city plans construction of intersecting sewer, pump station and treatment plant. C. E. Collins, Drexel Bldg., Phila., Pa., Engr.

Wis., Milwaukee—The city received bids for excavation and foundation for the Riverside Pumping Station, foot of Chambers St. from Schoonmaker Constr Co., 373 Bway., $161,300; S. M. Siesel, 105 Wells St., $164,000; W. H. Gillen, 902 Summit Ave., $164,000. Noted May 2.

Wis., Milwaukee—J. C. Heisa, 5010 Vliet St., is in the market for an air compressor complete with motor and tank.

Wis., Park Falls—The Flambeau Paper Co., G. Waldo, Mgr., is having plans prepared for a steel dam and equipment on Flambeau River. T. W. Orbison, Appelton, Engr.

Man., Windsor—The Avon Power Co. will soon receive bids for all work in connection with power plant on the Avon River to develop about 3,000 hp. to include a canal about 2,000 ft. long, 16 ft. depth, headworks, power house and dam. Estimated cost, $250,000. R. A. Jodrey, Wolfville, and T. B. Atkin, officials of the company.

N. B., St. John—The council plans to vote bond issue up to $900,000 for a distribution system for hydro electric power.

Ont., Carleton Place—The Bd. Educ., C. H. Abbott, Secy., plans to build a high school including a steam heating system. About $250,000. Richards and Abra, 126 Sparks, St., Ottawa, Archts.

Ont., Kitchener—The Kitchener & Waterloo School Bds., E. O. Weber, Chn., 337 King St., West, plans to build a 3 story collegiate and technical school including steam heating and motor driven ventilation system on King St. W. About $500,000. S. B. Coon & Son, 4 St. Thomas St., Toronto, Archts.

Ont., London—The London Health Resorts, Ltd., G .D. Brown, Pres., is having plans prepared for first unit of buildings to consist of bath houses, swimming pools, steam heating plant and plant for clarifying mineral water. About $400,000. W. G. Murray, Dominion Savings Bldg., Archt.

Ont., Ottawa—The Civic Hospital, Bd. Trustees, City Hall, will receive bids until May 25 for a heating and ventilating system; May 30 for a power house; June 1 for a service building. J. A. Evart, Archt.

Ont., Tavistock—The council, E. Parker, is having surveys made for electric lighting and power distribution system. About $27,000. A. Wilson, 190 University Ave., Toronto, Engr.

Ont., Pembroke—The Pembroke Electric Light Co., Ltd., will receive bids until June 1 for labor and material for a concrete dam at the High Falls on the Black River near here. About $60,000. J. L. Morris, Pembroke, Engr. J. Watt, Secy.

Que., Quebec—E. A. Robert, Pres. Montreal Tramway Co. and Pres. Quebec Railway Co., through Mayor Samson of Quebec has engaged experts to investigate water powers north of Quebec City with a view to extensive power development.

CONTRACTS AWARDED

Cal., Oakland—The Oakland City School Dist., Chabot Hall, has awarded the contract for a 2 and 3 story high school to R. W. Littlefield, 357 12th St., $353,800; heating to C. T. Doell, 467 21st St., $36,309. Noted March 14.

Cal., Palo Alto—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., has awarded the contract for the construction of a U. S. Veterans Hospital to Mahoney Bros., San Francisco, $844,500. Mechanical equipment to Turner Co., San Francisco, $286,000. Noted March 14.

Cal., Redwood City—County of San Mateo has awarded the contract for a steam heating and ventilating plant, boiler plant, etc., in the County Hospital to J. F. McGowan, 150 A St., $27,562. Noted May 2.

Ill., Chicago—Jones, Lenick & Schaefer, State and Van Buren Sts., have awarded the contract for a 3 story theatre at 17-25 West Madison St. to Van Etten Bros., 11055 South Michigan Ave. About $1,500,000. A steam heating system will be installed.

Ky., Louisville—Joseph & Joseph, 800 Francis Bldg., have awarded the contract for a 4 story, 200 x 300 ft. apartment on Willow and Baringer Ave. to C. A. Koerner, 318 East Burnett St., $500,000.

Me., Springvale—The Goodall Worsted Co., Sanford, has awarded the contract for a 5 story, 240 x 280 ft. mill and storehouse to W. M. Bailey Co., 12 Salem St., Boston. Estimated cost $700,000.

Mass., Greenfield—The town Building Committee has awarded the contract for a 2 story, 79 x 242 ft. high school on Federal and Sanderson Sts. to L. B. Taylor, 318 Main St., Athol, $378,000. Steam heating system to M. A. Dame & Sons Co., Lynn. Noted Feb. 14.

N. Y., Brooklyn—The Church of the Sacred Heart of Jesus and Mary, Bishop T. C. Malloy, 500 Hicks St., has awarded the contract for a 4 story, 72 x 121 ft. school on Hicks St. near DeGraw St. to Burke Bros. Constr. Co., 1476 Bway. Estimated cost $300,000. Noted March 11.

N. Y., Jamestown—Peterson & Woods, 313 North Main St., have awarded the contract for a 3 story theatre on Spring St. to Mullen, Guinnane & Ludwig, 303 North Main St. Estimated cost $550,000. A force system of heat and ventilation will be installed.

N. Y., New York—Manhattan College, 131st St. and Bway., has awarded the contract for a college on Spuyten Duyvil Pkway. to the Nugent Constr. Co., Inc., 21 East 40th Sts. About $1,000,000. Noted April 11.

N. Y., New York—Paterno & Son, 601 West 115th St., will build a 15 story apartment on West 88th St. About $1,500,000. Owner will build by day labor.

N. Y., New York—The Realty Sureties Co., Inc., c/o Carrere & Hastings, Archts., 52 Vanderbilt Ave., has awarded the contract for a 17 story hotel on Bway. and 104th St. to the Longacre Engrg. & Constr. Co., 562 5th Ave. About $1,500,000.

N. Y., New York—The Riverside Drive Corp., A. Sakolski, c/o G. F. Pelham, Archt., 200 West 42nd St., will build a 14 story apartment on Riverside Drive and 102nd St. About $1,000,000. Owner will build by day labor.

N. Y., New York—The Teachers College, Bway. and 120th St., has awarded the contract for a 70 x 195 ft. library and power house on 120th St. to Hegeman-Harris, 95 Madison Ave. About $1,500,000.

N. Y., New York—J. E. Waton, Inc., c/o Schwartz & Gross, Archts., 347 5th Ave., will build a 9 story, 50 x 100 ft. apartment on East 63rd St. About $450,000.

N. C., High Point—The Commercial Natl. Bank has awarded the contract for an 8 story, 50 x 150 ft. bank and office building to R. K. Stewart & Son, High Point. About $400,000. Noted March 14.

O., Cleveland—Fenwick Hall, c/o G. B. Post & Son, Archts., 101 Park Ave., New York City, has awarded the contract for a hotel to J. Gill & Son, Citizens Bldg. About $3,000,000.

Va., Richmond—The Richmond Trust Co., 7th and Main Sts., has awarded the contract for a 7 story, bank and office building to J. F. Wilson, Mutual Bldg. About $700,000.

Wash., San Francisco—The Bd. Public Wks. has awarded the contract for Contract 80. Prop. B.—Moccasin Creek Power Plant Hetch Hetchy Project, furnishing and delivering four 20,000 kva. electric generators to operate at a speed of 257 revolutions per min. and equipment, to the General Electric Co., Riaito Bldg., $260,285; Contract 79 A Prop. B., four 25,000 hp. water wheel units to operate at a speed of 257 revolutions per min. with individual oil pressure sets to Pelton Water Wheel Co., 19th and Harrison Sts., $248,800; Contract 79 B. Prop. 1, eight 36 in. gate valves with hydraulic operating cylinders to the Coffin Valve Co., Monadnock Bldg., $37,580. Noted March 14.

Wis., Spring Green — The city has awarded the contract for water mains to C. H. Phillips, Waupaca, tank and tower to the Pittsburgh Des Moines Bridge Co., 38 South Dearborn St., Chicago, Ill. Contract for pump and compensator to be let later.

Ont., Petrolea—The council has awarded the contract for a reservoir to A. Kilpatrick, Petrolea; steel tank to the Horton Steel Co., Buffalo and Bridgeburg, $14,600. Contract for pumps will be awarded later. Noted Dec. 20.